COTTON TESTING *Service*

TESTS AVAILABLE

EQUIPMENT AND TECHNIQUES

BASIS FOR INTERPRETING REPORTS

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UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICUTURAL MARKETING SERVICE • Cotton Division

CONTENTS

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COTTON TESTING SERVICE: TESTS AVAILABLE, EQUIPMENT AND TECHNIQUES, AND BASIS FOR INTERPRETING RESULTS

INTRODUCTION

This publication describes various cotton fiber and manufacturing tests available on a fee basis under the Cotton Testing Service Act (7 U.S.C. 473d), the method employed in making the tests, and the significance of the test results. A complete list of the tests available and the schedule of fees are shown in a companion publication entitled "Regulations of the Department of Agriculture for Cotton Fiber and Processing Tests" and identified as SRA-AMS 178.

The work of all of the laboratories performing service tests is supervised and coordinated through the Standards and Testing Branch of the Cotton Division, but the scheduling of the tests is handled by each individual laboratory. Special equipment required and the high degree of skill necessary for obtaining accurate test results have made it advisable to provide a certain degree of specialization in the making of such tests at the different laboratories (table 1). Addresses of the laboratories which perform the service tests are as follows:

Clemson Cotton Laboratory, Cotton Division, AMS
USDA, Box 67, Clemson, South Carolina 29631

College Station Cotton Laboratory, Cotton Division
AMS, USDA, Box 2977, College Station, Texas 77841

The following services other than those shown in table 1 are also provided under the service testing program:

USDA calibration cottons and color standards for calibration of Nickerson-Hunter Colorimeter are furnished by the Testing Section, Cotton Division AMS, USDA Box 17723, Memphis, Tennessee 38117

Air-flow tests of micronaire reading are available in connection with the classification of cotton at all of the classing offices of the Cotton Division

SELECTION OF TESTS AND SAMPLES

In making requests for tests, it should be borne in mind that each test is designed to give specific information regarding some phase or phases of cotton quality. Only those tests that will furnish helpful data in explaining the cotton quality problems being studied should be requested. A well-planned test will generally yield more useful data on a specific problem, and may cost less than a carelessly planned test. Selection of the tests desired is, of course, a matter for the applicant to decide. Suggestions regarding the most suitable tests for solving specific problems may be obtained from any of the laboratories. Requests for suggestions should outline briefly the purpose for which the service tests are needed and place of growth or other pertinent information. By reviewing Department of Agriculture publications that show spinning and fiber properties of various varieties and growths of cotton, applicant may obtain suggestions that will be helpful in determining the kind of tests best suited for his purpose.

Table 1.--Service tests available at each of the testing laboratories operated by the Cotton Division

Types of Tests	Location of Laboratory	
	Clemson S. C.	College Station Texas
Fiber tests:		
Classification and fiber tests	Yes	Yes
Color of raw cotton	Yes	Yes
Foreign material content	Yes	Yes
Blending test samples	Yes	Yes
Length (array)	Yes	Yes
Length (Fibrograph)	Yes	Yes
Strength (0-gauge)	Yes	Yes
Strength (1/8-inch gauge)	Yes	Yes
Micronaire	Yes	Yes
Fineness and maturity (Causticaire)	Yes	Yes
Raw stock nep content	Yes	Yes
Moisture content	Yes	Yes
Processing and finishing tests:		
Carded yarn spinning 1/	Yes	Yes
Combed yarn spinning 1/	Yes	No
Slashing and weaving 2/	Yes	Yes
Finishing tests 3/	Yes	Yes
Other tests:		
Furnishing identified samples	Yes	Yes
Furnishing copies of results	Yes	Yes

1/ Includes all extra items performed in connection with spinning tests and other items which are a part of the spinning test.

2/ Includes spinning of the yarn and testing of the fabric in connection with spinning tests.

3/ Includes spinning and finishing of the yarn and testing for color in connection with spinning tests.

Results of the fiber and processing tests can be no more representative of cottons than are the samples themselves; therefore, the proper size, selection, and preparation of samples are extremely important. The following suggestions relative to the selection and preparation of samples are designed to aid applicants for testing services in obtaining the most reliable results possible:

Size.--1 ounce or more for fiber tests
6 pounds or more for each carded yarn spinning test
8 pounds or more for each combed yarn spinning test
10 pounds or more for carded and combed yarn spinning tests.

In view of the high degree of variability found for all measurable properties of cotton within a bale it is very important that care be exercised by applicants in selecting the samples that are to be forwarded to the laboratories for testing. Otherwise the samples may not be truly representative of the cotton from which they were extracted and an erroneous impression may be formed. A more detailed discussion of the problem of variability of cotton appears in a subsequent section of this report.

FIBER TESTS AND THEIR EVALUATION

The quality of cotton is traditionally designated in terms of grade and staple classification as determined by skilled cotton classers. Laboratory test measurements have also been developed to provide additional quality information to supplement the usual classification results. Most of these fiber tests are performed in a standard atmosphere of 70 degrees F. and 65 percent relative humidity after the samples have been conditioned in moving air of the standard atmosphere (fig. 1). Details of the various fiber tests and their evaluation are discussed in subsequent paragraphs.

Classification for grade and staple. Grade is a combination of the color, leaf and preparation of a sample of cotton. Staple length is the length of a typical portion of the fibers in the sample as determined by the classer. The classification of samples for these items is actually performed in classing laboratories of the Cotton Division, AMS, USDA, in accordance with the Universal standards for grade and the official standards for staple length.

Classification is usually obtained directly from the classing offices but it is available through the laboratories when other tests are requested on the same samples. Classification results are also furnished with each spinning test lot. The classification procedure is fully described in Miscellaneous Publication No. 310 of the United States Department of Agriculture entitled "The Classification of Cotton."

Color tests. This test is an instrument measure of the color factor included in grade. It includes reflectance in terms of R_d values and the degree of yellowness in terms of b values as measured by an automatic electronic instrument, the Nickerson-Hunter Cotton Colorimeter (fig. 2). The R_d scale measures percentage of reflectance from 0 to 100 and the b scale provides a measure of yellow to blue. Cotton that has good bright color is high in reflectance, but dark colored cottons have low reflectance. The portion of the b scale used on the Cotton Colorimeter indicates an increasing degree of yellowness as the scale number increases. The color of any cotton consists of a combination of its R_d and b measurements. It can be very misleading to consider them as separate factors. Color tests require samples having a uniform surface measuring at least 5 x 6-1/2 inches and weighing at least 50 grams to provide smooth specimens which are sufficiently thick to be opaque. The regular test provides color readings on individual samples of cotton submitted by the applicant. One special test item provides color diagrams of official grade standards purchased by the applicant. Another test item provides a set of color standards and a master diagram for use in calibrating Nickerson-Hunter Cotton Colorimeters.

Figure 1.--General view of fiber laboratory

Figure 2.--Technician performing raw stock color tests

Color values for specific samples of cotton may be compared with the color of the cotton in the official grade standards for American upland cotton by either plotting them on a special diagram (fig. 3) or converting them to a code as shown on the diagram. The first digit of the 3-digit code relates to grade as indicated by number 3 for Good Middling through 9 for Good Ordinary. The second digit of the code relates to placement within the grade as indicated by 0 for the upper half and by 5 for the lower half. The third digit in the code relates to yellowness as indicated by numbers 1 for the whitest side of the grades through 9 for the color of the yellow stained grades. The color values for specific American Egyptian cottons may also be plotted on a special diagram (fig. 4) for comparison with the color of the cotton in the official grade standards of these cottons.

Special studies and practical experience have indicated the following reproducibility of the results of these tests:

Color test measurement	Significant difference
Reflectance (R_d)	0.3
Yellowness (b)	0.3

Nonlint test. This test is an instrument measure of the trash factor included in grade. Single samples of approximately 100 grams each are weighed and processed twice through the Shirley Analyzer (fig. 5). The lint and trash are separated by the machine and are weighed to provide the basis for the calculation of nonlint content or percentage of waste. Nonlint content determined by Shirley Analyzer tests differs from total picker and card waste determined by spinning tests. The nonlint contains practically no fiber but the wastes removed by the textile mill cleaning machines contain appreciable amounts of fiber. Both ginned lint and various types of wastes can be analyzed for nonlint content by this method.

Nonlint content is related to the grade designation of the cotton, but the results for individual samples may vary considerably from the average of that grade. Intentional differences in the trash content are included in each grade to offset difference in color and provide a range. Additional differences are caused by the nonlint data being based on weight without any consideration of the visual appearance of the trash, which is very important in the grade designation. Tests performed in recent years on samples of cotton from the bales used in the Standards and from surveys of the crop show the following average relationship of Shirley Analyzer nonlint to grade:

American upland grade	Average nonlint content (percent)	American Egyptian grade	Average nonlint content (percent)
Good Middling	1.5	1	1.1
Strict Middling	1.6	2	1.9
Middling	2.2	3	2.7
Strict Low Middling	3.1	4	3.6
Low Middling	4.5	5	4.4
Strict Good Ordinary	5.8	6	5.3

Data source - 2897 American upland lots tested from crops of 1960-62 and 158 American Egyptian lots tested from the crops of 1956-60.

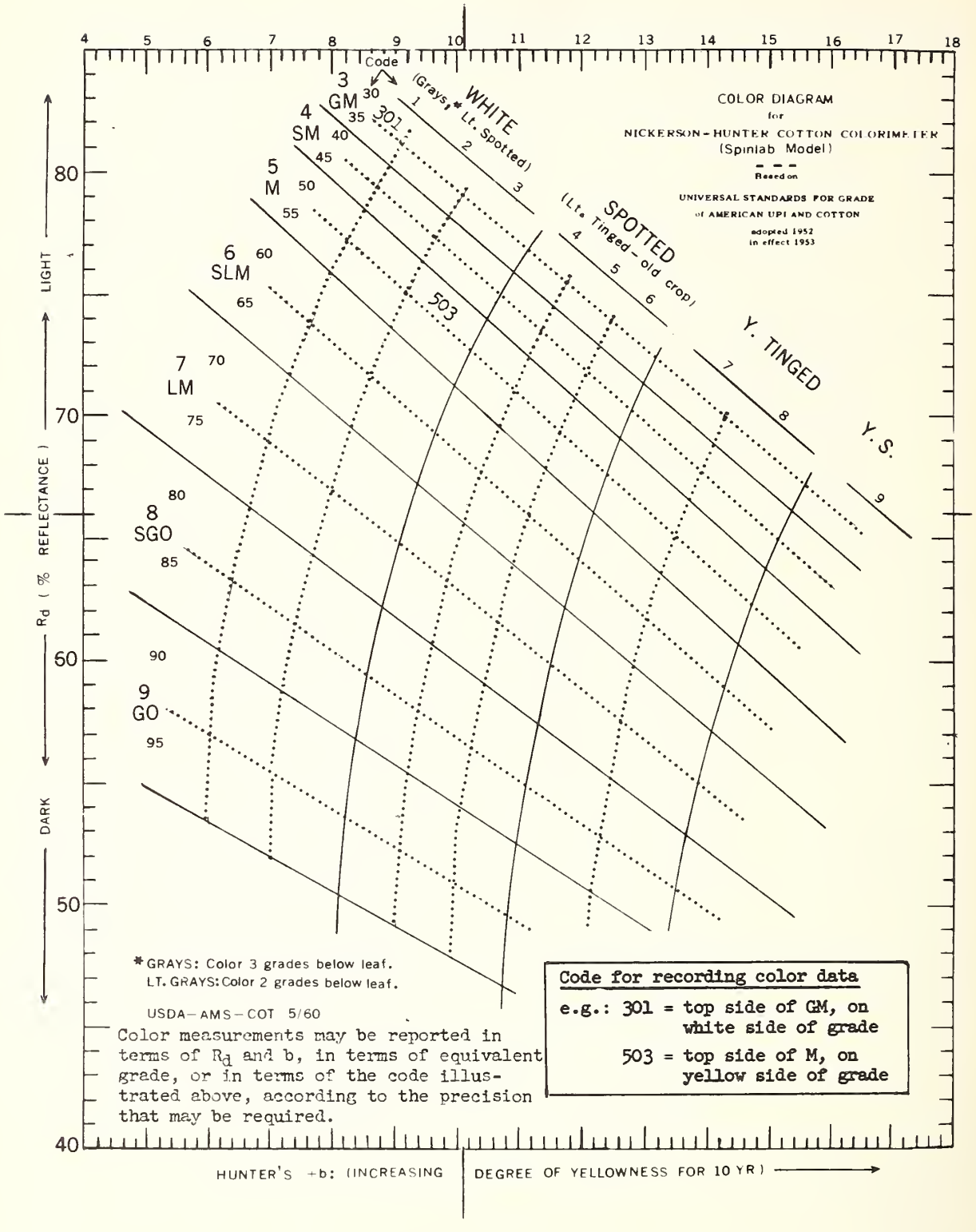

Figure 3.--Color diagram for American upland cotton.

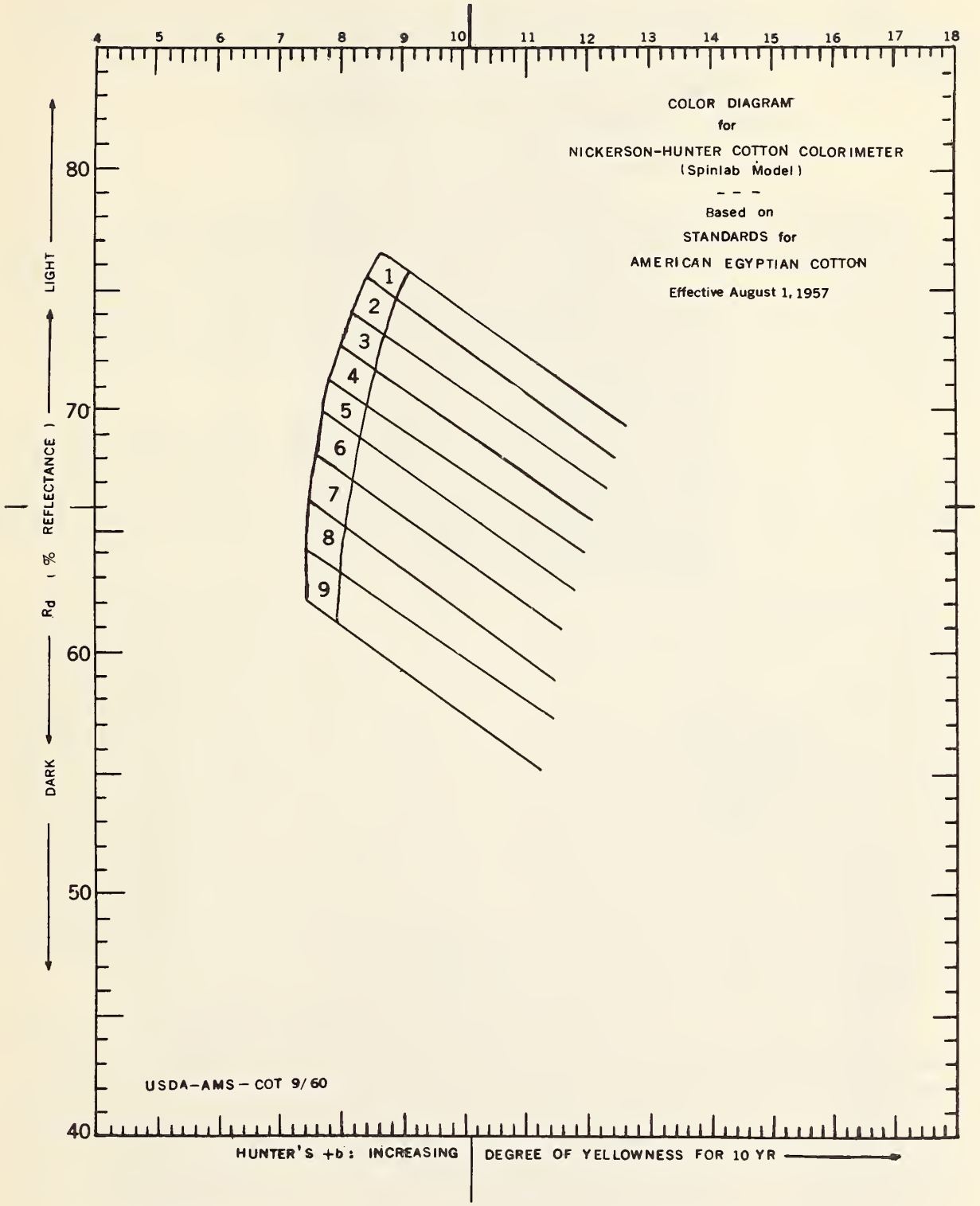

Figure 4.--Color diagram for American Egyptian cotton.

Special studies and practical experience have indicated the following approximate accuracy of the reproducibility of individual Shirley Analyzer tests:

Shirley Analyzer test measurement	Significant difference
Nonlint content (percent)	0.5

Blending fiber test samples. In view of the relatively small quantity of cotton used as specimens with many laboratory test instruments, it is highly important that these specimens be representative of the entire sample. To accomplish this, a number of pinches of cotton are taken at random from different parts of the sample provided and these pinches are blended on a mechanical blender (fig. 6). The blender mixes the individual fibers into a practically homogeneous mass and specimens taken from any part of the blended sample are representative.

Specimens for fiber tests described herein which require small amounts of cotton are taken from a mechanically blended sample except for the subsample Fibrograph length, Pressley strength and Micronaire tests. A special test item provides a means for the applicant to obtain a mechanically blended sample for fiber tests in his own laboratory.

USDA calibration samples. In order to obtain comparable results in different laboratories or in the same laboratory at different times it is necessary to test cottons with established values and to calibrate the results to the same level. Calibration samples for this purpose are offered in response to a request from the American Society for Testing Materials to meet the needs of those who operate their own laboratories. A 1-pound sample of short, medium or long staple American upland cotton or extra long staple American Egyptian cotton is furnished for laboratory check tests. Established standard fiber test values are also furnished with each sample for all test items routinely employed by the Cotton Division laboratories except for airflow measurement of micronaire reading and Pressley strength at zero gauge. Standard values have been established internationally on special samples for these tests which are used widely in commercial transactions. The International Cotton Calibration Standards for these items are also available from the Cotton Division, AMS. The use of these calibration samples provides an opportunity for each laboratory to correlate his results with those obtained in other laboratories making similar tests.

Array fiber length test. This test is an instrument measure of length closely associated with staple length and also includes measures of fiber length distribution. The fibers in small representative samples of cotton are parallelized by pulling them through a series of combs in the Suter-Webb fiber sorter (fig. 7). The fibers are arrayed according to length (fig. 8) and are separated into different length groups at 1/8-inch intervals. Each length group is accurately weighed to obtain the length-weight distribution for use in calculating various fiber length values.

Alternative array tests include average results for upper quartile length, mean length, coefficient of length variation and percentages of fibers in each 1/8-inch length group calculated from 3 arrays or calculated from 2 arrays.

Figure 5.--Technician performing nonlint tests.

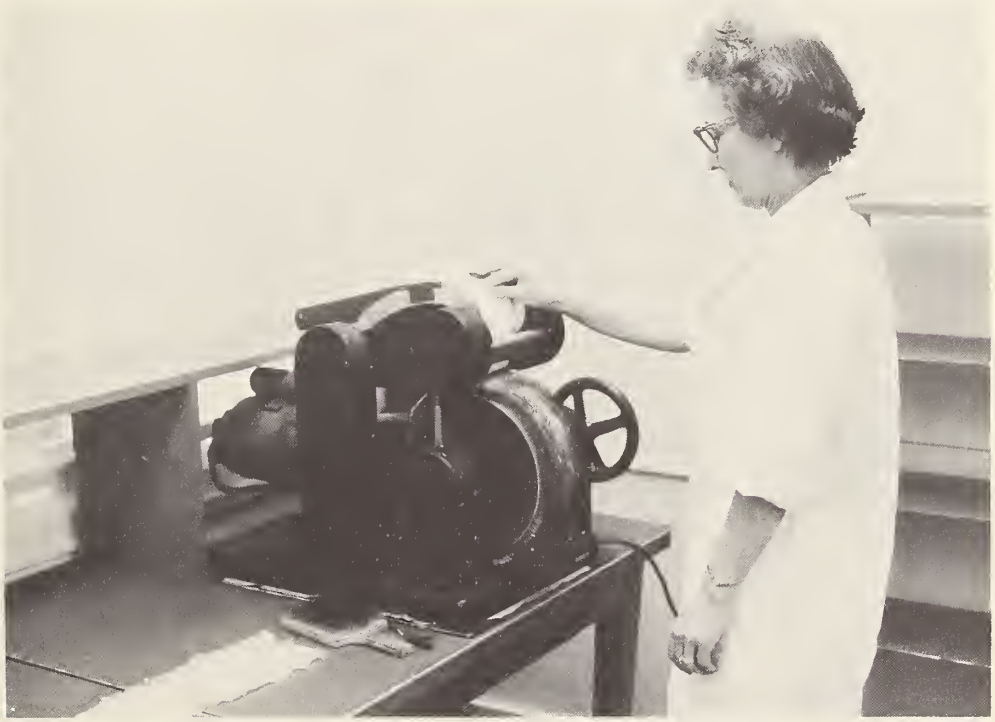

Figure 6.--Technician blending a fiber test sample.

A special array test includes the detailed data required in connection with the United States Pharmacopoeia Standards for absorbent cotton. It includes the percentage of fibers 1/2-inch and longer and the percentage shorter than 1/4-inch in addition to the values usually reported. A short-cut or truncated array includes average results for mean length, uniformity of length and percentage of fibers longer than 1/2-inch calculated from 3 arrays. All array tests are performed on blended samples.

Upper quartile length represents the length for which 25 percent of the fibers by weight in a sample are longer. Cottons having long upper quartile lengths are desirable because they can be spun into finer yarn numbers which are used in the higher quality end-products. Upper quartile length is related to classer's staple length but this relationship may vary because the array method does not select and measure a typical portion of fibers as required in designating staple length.

The mean length is a measure of the average of all fibers in the sample calculated from the weight-length distribution. The coefficient of length variation is the standard deviation of the weight-length frequencies expressed as a percentage of the mean length. It is a relative measure of the variability of the length of the fibers in the sample tested. Large values indicate irregular fiber length and small values indicate uniform fiber length. Excessive variation in the fiber length distribution tends to increase manufacturing waste, to make processing more difficult and to lower the quality of the product. Low coefficient of length variation is therefore a desirable cotton quality characteristic. Other measures of length variability, such as percentage of fibers shorter than 1/2-inch, percentage of fibers in each length group, and others are frequently used for special purposes.

Figure 7.--Technician performing array fiber length tests.

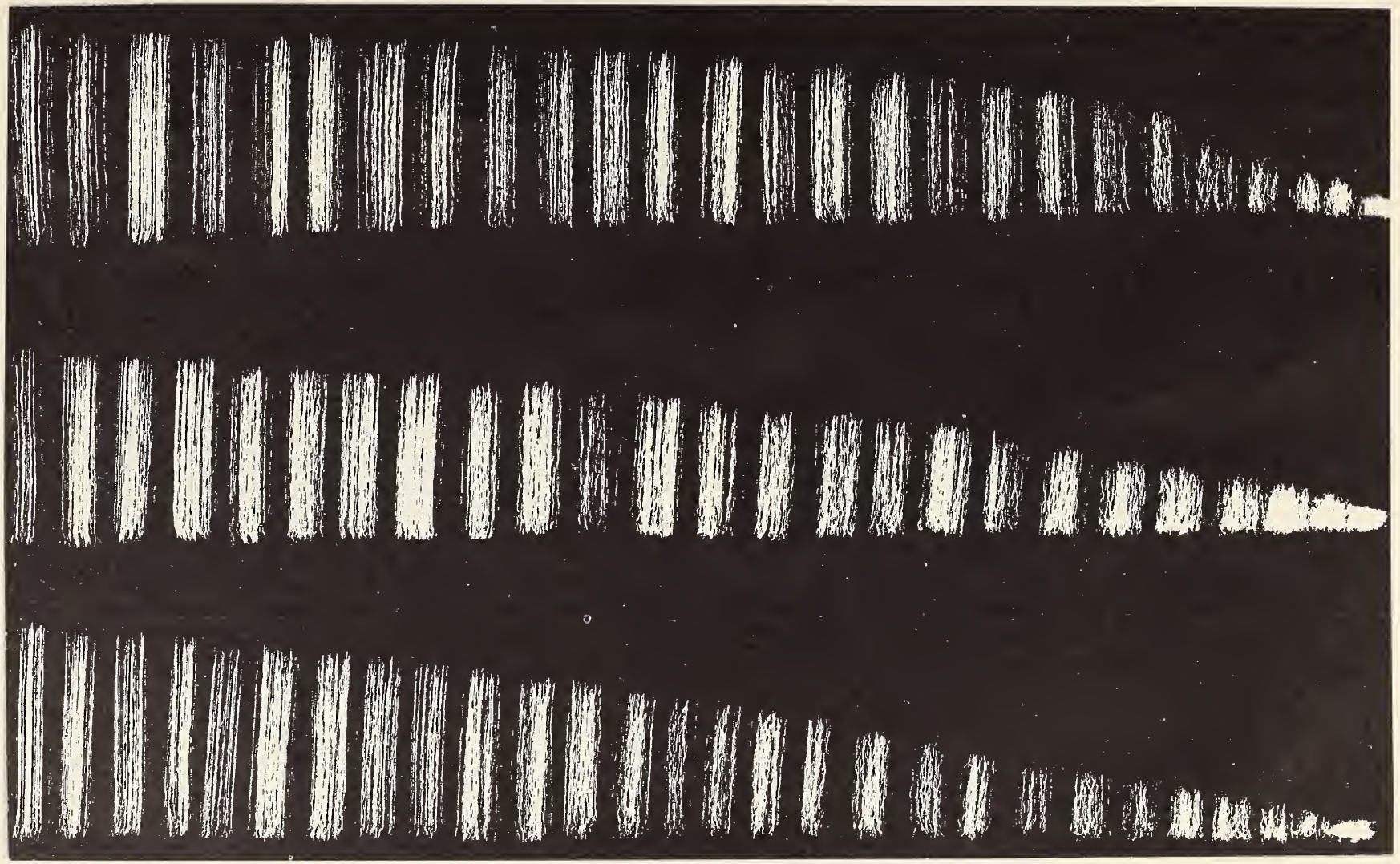

Figure 8.--Fiber length arrays of three cottons showing a range of length variability.

The following descriptive designations are based on cottons tested in recent years and will aid in the comparison between cottons:

Array length distribution

Coefficient of length variation (percent)	Descriptive designation
Below 26	Very low variation
26 to 29	Low variation
30 to 33	Average variation
34 to 37	High variation
Above 37	Very high variation

Data source - 830 American upland lots tested from crops of 1958-60.

All results reported for the array fiber length tests are based on either 2 or 3 arrays for each sample tested. Special studies and practical experience indicate the following approximate reproduciability of the array test results:

Array test measurement	Significant difference
Upper quartile length (inches)	0.02
Mean length (inches)	.02
Coefficient of length variation (percent)	2

Fibrograph fiber length test. This test is another instrument measure of length closely associated with staple length and also includes measures of fiber length distribution. The fibers in a representative sample of cotton are placed at random in the teeth of a pair of combs to provide the test specimen. The portion of the fibers protruding from the outside edge of the combs is combed to form a parallelized test beard. The Fibrograph instrument photoelectrically scans the test beard from the short fiber portion to the long fiber portion at the beard's extremity (figs. 9 and 10). The amount of light passing through the beard to the scanning photocell increases as the bulk of the fibers decreases. The manual, Servo and Digital models represent different stages in the development of a more automated Fibrograph instrument. The length-frequency distribution of the fibers in the sample is registered as a second cumulation curve on both the manual and Servo models. When using the Digital model, values are registered as direct readings of both the length and the amount of fiber coordinates of this curve when the instrument is stopped at selected points on the curve. Length values are obtained graphically from the curve for the manual and Servo models and from direct readings for the Digital model. These length values are also used to calculate measures of length uniformity.

The regular Fibrograph test includes average results for upper half mean length, mean length, and mean/UHM uniformity ratio for 4 determinations performed on a blended sample for either the manual or Servo models. It also includes average results for 2.5 percent span length, 50 percent span length, and 50/2.5 uniformity ratio for 4 determinations performed on a blended sample for the Digital model. The subsample Fibrograph test includes the same measurements reported for the regular test, but each value is the average of 2

Figure 9.--Technician performing Fibrograph length tests on the Servo model.

Figure 10.--Technician performing Fibrograph fiber length tests on Digital model.

determinations performed on each of a number of replicate unblended subsamples by using either the manual, Servo, or Digital models. The special Digital Fibrograph test includes the average results of the short fiber content measurement for 4 determinations performed on a blended sample in addition to the usual measurements reported.

Upper half mean length from the manual and Servo models is theoretically a different measure of fiber length than the 2.5 percent span length from the Digital model, but they are essentially the same in practical application. The upper half mean length is a measure of the average length of the longer half of the fibers in a sample of cotton; whereas, the 2.5 percent span length is a measure of the length spanned by 2.5 percent of the fibers in a sample of cotton when they are parallelized and randomly distributed. Cottons having long upper half mean length and 2.5 percent span length are desirable because they can be spun into finer yarns which are used in the higher quality end products. The Fibrograph length measurements are usually closely related to the classer's staple length designation but their relationship to classer's staple length may vary because the Fibrograph method does not select or measure a typical portion of fibers as required in designating staple length.

The mean length is a manual or Servo Fibrograph measure of the average length of the fibers in a sample of cotton and 50 percent span length is a Digital Fibrograph measure of the length spanned by 50 percent of the fibers in a sample of cotton when they are parallelized and randomly distributed. These two values are on entirely different levels but they are both used in conjunction with other length measures to provide uniformity ratios. Large values for each of the uniformity ratios indicate uniform fiber length and small values for each of these ratios indicate irregular fiber length. High uniformity in fiber length tends to decrease manufacturing waste to make processing less difficult and to raise the quality of the product. High uniformity ratio is, therefore, a desirable cotton quality characteristic. Other measures of length distribution such as short fiber content are related to length uniformity. The following descriptive designations are based on cottons tested in recent years and will aid in the comparison between cottons:

Fibrograph length distribution

Uniformity ratio (percent)		Descriptive
M/UHM	50/2.5	designation
Below 74	Below 42	Very low uniformity
74 to 76	42 to 43	Low uniformity
77 to 79	44 to 45	Average uniformity
80 to 82	46 to 47	High uniformity
Above 82	Above 47	Very high uniformity

Data source - 2066 American upland lots tested from crop of 1958-60 for M/UHM and 2897 American upland lots tested from crop of 1960-62 for 50/2.5.

All results reported for the Fibrograph length tests are based on either 2 or 4 readings on each sample. Special studies and practical experience have indicated the following approximate reproducibility of the Fibrograph test results:

Fibrograph test measurement	Significant difference
Upper half mean or 2.5 percent span length (inches)	0.02
M/UHM or 50/2.5 uniformity ratio	2

Fiber strength test. This test is an instrument measure of another quality factor which is not included in grade and staple classification. Fibers in a small representative sample of cotton are hand-combed to parallelize them into a flat ribbon or bundle about 3/16 to 1/4-inch wide. The flat bundle is placed in a set of breaking clamps and the protruding ends are cut to a definite length. This prepared bundle of fibers in the clamps is broken in the Pressley strength tester (fig. 11). The broken specimen is weighed to determine the amount of fiber broken in the test. The strength of the specimen, as indicated on the beam of the machine is read to the nearest tenth of a pound and the weight of the specimen is read to the nearest hundreth of a milligram as a basis for the calculation of the fiber strength results.

The regular fiber strength test includes average strength results for 6 determinations performed on a blended sample; whereas, the subsample test includes the average strength for 2 determinations performed on each of a number of replicate unblended subsamples. Both of these test items may be used for either zero gauge or 1/8-inch gauge strength tests. The zero gauge tests are more commonly used in the cotton trade, but the results of the 1/8-inch gauge tests are more highly correlated with spinning test results. Fiber strength is an important factor in determining the strength of the yarns produced from different cottons. The high strength cottons usually give less trouble in processing than the low strength cottons.

The results of the zero gauge tests are reported in terms of thousand pounds per square inch and also in grams per tex. The results reported may be converted to the other terms of expression for fiber strength by applying the following formulas:

$$S_2 = (S_1 + 0.12) / 10.81$$

$$S_2 = S_3 / 5.36$$

$$S_3 = (S_1 + 0.12) \times 0.496$$

Where: S_1 = Thousand pounds per square inch (zero gauge)

S_2 = Strength-weight ratio (zero gauge)

S_3 = Grams per tex (zero gauge)

The following descriptive designations are based on cottons tested in recent years and will aid in the comparison between cottons:

Fiber strength (zero gauge)

Thousand psi	Grams per tex	Descriptive designation
Above 90	Above 45	Very high strength
84 to 90	42 to 45	High strength
77 to 83	38 to 41	Average strength
70 to 76	34 to 37	Low strength
Below 70	Below 34	Very low strength

Data source - 2897 American upland lots tested from crops of 1960-62.

The results of the 1/8-inch gauge tests are reported in terms of grams per tex. The results reported may be converted to other terms of expression for fiber strength by applying the following formulas:

$$S_5 = S_4 / 6.80$$

$$S_6 = S_4 / 0.217$$

Where: S_4 = Grams per tex (1/8-inch gauge)

S_5 = Strength-weight ratio (1/8-inch gauge)

S_6 = Fiber strength index (1/8-inch gauge)

There is a high correlation between 1/8-inch gauge fiber strength results and fiber length. Short staple cottons, therefore, tend to have lower 1/8-inch gauge strength values than long staple cottons. Tests in recent years have shown approximately the following relationships between staple length and fiber strength:

Fiber strength (1/8-inch gauge)

Staple length group	Average strength (grams per tex)
American upland:	
Short staple	20
Medium staple	22
Long staple	24
American Egyptian:	
Extra long staple	33

Data source - 2897 American upland lots tested from crops 1960-62 and 158 American Egyptian lots tested from crops of 1956-60.

Fiber elongation results can be obtained in connection with 1/8-inch gauge fiber strength tests by using a Stelometer instrument instead of the Pressley instrument (fig. 12).

Figure 11.--Technician performing fiber strength tests on Pressley tester.

Figure 12.--Technician performing fiber strength test on Stelometer instrument.

All results reported for fiber strength tests are based on either 2 or 6 determinations on each sample. Special studies and practical experience have indicated the following approximate reproducibility of the fiber strength test results:

Fiber strength measurement	Significant difference
Zero gauge tests:	
Thousand pounds per square inch	2
1/8-inch gauge tests:	
Grams per tex	0.5

Fiber fineness and maturity test. This test is an instrument measure of quality factors which is not included in a grade and staple classification. The test is performed with air-flow instruments which indicate the resistance to the passage of air under specified pressure through a specified weight of cotton when it is compressed to a specified volume (fig. 13). Micronaire, Fibronaire, Port-ar, and others are commercial instruments which can be used for these tests. The Causticaire tests provide separate measures of fineness and maturity and the tests of micronaire reading provide a measure of these two properties in combination. Both the Causticaire test and one of the micronaire reading test items are based on 2 determinations performed on a blended sample. Another Micronaire test item is based on 1 determination performed on each of a number of replicate unblended subsamples.

Fineness is a relative measure of either the weight per unit length or the cross sectional size of the fibers; whereas maturity is a relative measure of the cell-wall development of the fiber. Both fiber fineness and fiber maturity are important factors of cotton quality but they are closely related. Fineness contributes to the production of high strength yarns particularly when fine yarn numbers are spun and also tends to increase neppiness which requires a reduced rate of processing. Fiber maturity contributes to the production of yarns and fabrics with good appearance and to the decrease in the amount of picker and card waste removed in processing. Fiber immaturity on the other hand contributes to the formation of more neps and the production of yarns with low appearance grades. The desirability of fineness and maturity depends on the specific end product or use of the cotton.

The air-flow tests of micronaire reading are used extensively in cotton marketing and manufacturing operations. They are much more rapid than the other fineness and maturity tests and provide essentially the same information. The scales for the air-flow instruments were initially set up to indicate a direct reading in micrograms per inch of fiber. The term used to express the results, however, was changed from "micrograms per inch" to "micronaire reading" because these results may differ from the actual weight per inch depending on the maturity and other fiber characteristics of specific samples. The micronaire reading scale is now used internationally. The following descriptive designations are based on American upland cottons tested in recent years and will aid in the comparison between cottons:

Micronaire reading	Descriptive designation
Below 3.5	Very low
3.5 to 3.9	Low
4.0 to 4.4	Average
4.5 to 5.0	High
Above 5.0	Very high

Data source - 2897 American upland lots tested from crops of 1960-62.

The Causticaire test requires a special scale which is proportional to the flow of air. The method consists of air-flow measurements with this special scale on specimens of cotton both before and after being treated with a standard solution of sodium hydroxide, rinsed and dried (fig. 14). The causticaire treatment swells the fibers causing them to straighten out and become cylindrical in shape. The ratio between the measurements on the untreated specimen and the treated specimen provides a relative measure of maturity. This maturity value reflects the degree of cell-wall development throughout the entire length of the fibers. The fineness or weight per inch is calculated from a combination of the measurement of the treated specimen and the maturity index of the specimen tested. These Causticaire fineness values approximate very closely the actual weight per inch of the fiber for all botanical types of cotton and ranges of maturity. These test results are calculated from the two air-flow readings by applying the following formulas:

Where: $MI = UT \times 100/T$

$F = 1.185 + (0.00075 \times T^2) - (0.020 \times MI)$

MI = Causticaire maturity index in percent

UT = Causticaire reading on untreated specimen

T = Causticaire reading on treated specimen

F = Causticaire fineness in micrograms per inch

The descriptive designations listed above for micronaire reading may also be applied to causticaire fineness. The following descriptive designations for maturity are based on cottons tested in recent years and will aid in the comparison between cottons:

Causticaire maturity index	Descriptive designation
Below 72	Very low
72 to 75	Low
76 to 79	Average
80 to 83	High
Above 83	Very high

Data source - 2750 American upland lots tested from crops of 1958-60.

Figure 13.--Technician performing tests for micronaire reading by Air-flow instrument.

Figure 14.--Technician treating samples for Causticaire tests.

All results reported for fineness and maturity tests are based on either 1 or 2 determinations per sample. Special studies and practical experience have indicated the following approximate reproducibility of the fineness and maturity test results:

Fineness and maturity test measurement	Significant difference
Air-flow micronaire reading	0.2
Causticaire micrograms per inch	0.2
Causticaire maturity index (percent)	2

Nep test. A nep is one or more fibers occuring in a tangled and unorganized mass. Cotton neps are created by the fibers becoming tangled during the harvesting, ginning, and processing operations. Cottons differ in their susceptability to the formation of neps because of various varietal and invironmental factors. The occurrence of neps in appreciable numbers is undesirable because they may be a source of trouble in the manufacturing and finishing of yarns and fabrics. The effect of neps on cotton processing is discussed more fully in a subsequent section of this report "Neps in card web."

In this item a 3-gram sample is blended on the mechanical blender. This blended sample is then processed into a thin web using special equipment developed for this purpose (fig. 15). The neps in ten 4 x 9-inch specimens of the web are counted by each of two technicians and the results are expressed in terms of number of neps in 100 square inches of web.

This test method was designed primarily for the study of different cleaning equipment at the cotton gin. Tests on the same cotton before and after cleaning provide an indication of the effect of the cleaning equipment in increasing the number of neps or the nep potential of the cotton.

All nep content results reported are based on ten 36 square inch specimens per sample. Special studies and practical experience have indicated the following approximate reproducibility of the nep test results:

Nep test measurement	Significant difference
Neps per 100 square inch of web	3

Moisture test. Cotton is very hygroscopic in that it readily takes up and gives off moisture when exposed to different atmospheric conditions. Tests for moisture content are performed by using a drying oven (fig. 16). The regular test covers the determination of moisture content of ginned cotton lint, cotton stock at various stages of processing, cotton yarn and cotton waste. Samples for these tests are usually either weighed to provide 20-gram specimens when taken for the tests or are placed in air-tight containers to maintain constant moisture until they are tested. In performing these tests, the weight of the specimen is obtained both before and after being dried in drying ovens. The moisture content of cotton samples may

Figure 15.--Technician performing nep tests.

Figure 16.--Technician performing moisture tests.

vary from below 5 percent in dry air to over 15 percent in humid air. The moisture content based on a 20-gram specimen is calculated by applying the following formula and is reported to the nearest one-tenth of one percent:

$$\text{Moisture content percentage} = \frac{(20.00 \text{ grams} - \text{dry weight}) \times 100}{20.00 \text{ grams}}$$

A special test item covers the determination of moisture regain of ginned cotton lint at 92 percent relative humidity. In performing these tests, specimens are suspended in the air above a saturated solution of sodium bromide in a closed container. After the specimens have reached moisture equilibrium in this moist air, they are placed in weighing bottles and weighed both before and after drying in a drying oven. The moisture regain based on two specimens of approximately 1/2-gram is calculated by applying the following formula and is reported to the nearest one-tenth of one percent:

$$\text{Moisture regain percentage at 92 percent RH} = \frac{(W_1 - W_2) \times 100}{W_2 - W_3}$$

Where: W_1 = Weight of conditioned specimen and bottle
W_2 = Weight of dried specimen and bottle
W_3 = Weight of bottle

High moisture regain at a specified relative humidity is considered desirable by the cotton textile industry and low moisture regain is considered an indicator of probable mechanical or heat damage.

Sugar and acid-alkalinity tests. In these tests specimens of cotton are saturated with boiling distilled water and are centrifuged to obtain water extracts (fig. 17). These extracts are tested for both sugar content and acid-alkalinity. The soluble reducing sugar content is determibed by comparing the color of the extract with working standards of known sugar content after Clinitest tablets have been added. High sugar content is associated with difficulty in textile processing and with lower yarn appearance grades. Inasmuch as the sugar content of cotton decreases as the fibers mature, a relatively high sugar content for the cotton of normal maturity indicates contamination with honeydew. The presence of a relatively high concentration of sugar in immature cottons, however, may be attributable either to fiber immaturity, honeydew, or both. Although the critical point in sugar content has not been established definitely from the standpoint of adverse effect on textile processing, this point is probably in the neighborhood of 0.3 percent reducing sugar. Cottons with sugar content in excess of that percentage may give trouble in processing

The acid-alkalinity of the water extract is determined with a pH meter. Values below 7.0 indicate acidity and those above 7.0 indicate alkalinity. Values above 7.0 when associated with low sugar content may indicate fiber deterioration due to weathering or from the actions of micro-organisms. Such deterioration, however, is usually detectable by either the grade or color measurement of the cotton.

One test item includes determinations of sugar content only, another item includes acid-alkalinity only, and another includes a combination of both of these measures. The following descriptive designations are based on cottons tested in recent years and will aid in the comparison between cottons:

Sugar content (percent)	Acid-alkalinity (pH value)	Descriptive designation
	Above 10	Very high
Above 0.3	9 to 10	High
0.1 to 0.3	7 to 8	Average
Below 0.1	5 to 6	Low
	Below 5	Very low

Data source - 2750 American upland lots tested from the crops of 1958-60.

Special studies and practical experience have indicated the following reproducibility of the results of these tests:

Test measurement	Significant difference
Sugar content (percent)	0.2
Acid-alkalinity (percent)	0.3

PROCESSING TESTS AND THEIR EVALUATION

In the final analysis, the actual results obtained in processing different samples of cotton and in the testing of the resulting yarns provide the most satisfactory basis for evaluating the relative merits of the cotton represented by such samples. Laboratory equipment and techniques have now been developed to a point where reliable spinning test results can be obtained from small samples of cotton using commercial-type processing machinery. A brief description of these processes is given in subsequent paragraphs.

In these tests, the test sample is opened by hand and processed twice through a finisher picker (fig. 18). This machine cleans the cotton with a rotary Kirschner beater, screens, and air draft. A blade beater is used for long staple cottons. The sample is collected on a condenser screen and is delivered in the form of a layer which is called a lap.

The lap from the picker is processed through a card (fig. 19). This machine disentangles the mass of fiber and removes fine trash, other particles of foreign material, and some fiber. The disentangled fibers are condensed first into a thin layer called a web and then into a rope-like strand called a sliver.

For combed yarn tests, the card sliver is processed first through a sliver lapper (fig. 20), and then through a ribbon lapper (fig. 21), before being fed to the comber. These two machines combine a number of strands for uniformity and draft or draw out the fibers to make them more parallel. The sample from the ribbon lapper is processed through the comber (fig. 22). This machine combs out short fibers and forms the remaining fibers into sliver.

Either the card sliver for carded yarns or the comber sliver for combed yarns is fed to a drawing frame (fig. 23). This machine combines a number of strands for uniformity and drafts or draws out the fibers to make them more parallel and delivers them as sliver. Two processes of drawing are used for both carded yarns and combed yarns.

Figure 17.--Technician performing sugar and acid-alkalinity tests.

Figure 18.--Technician processing test sample through the picker.

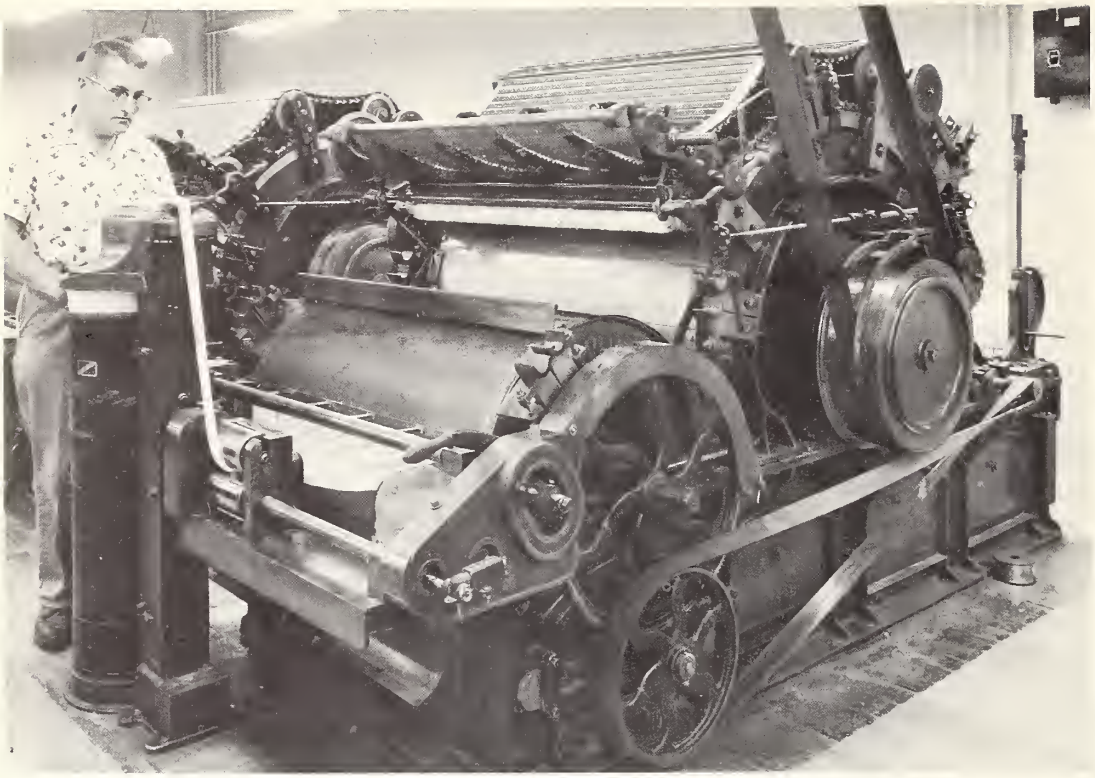

Figure 19.--Technician processing test sample through card.

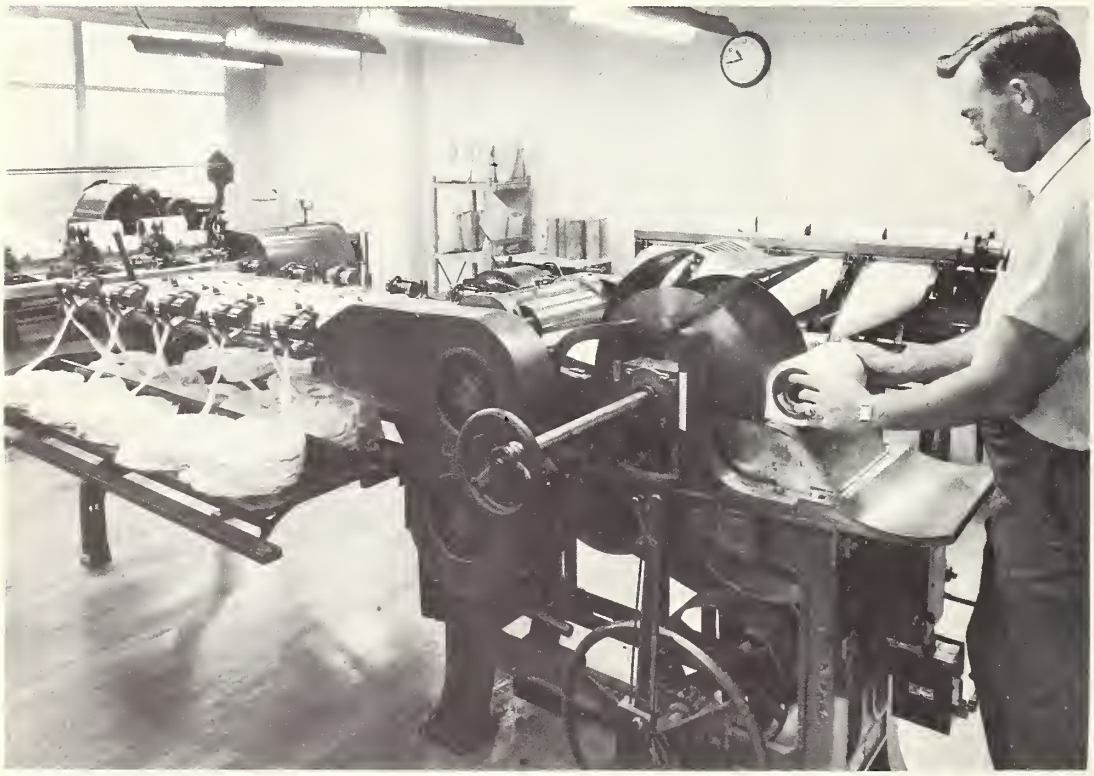

Figure 20.--Technician processing test sample through sliver lapper.

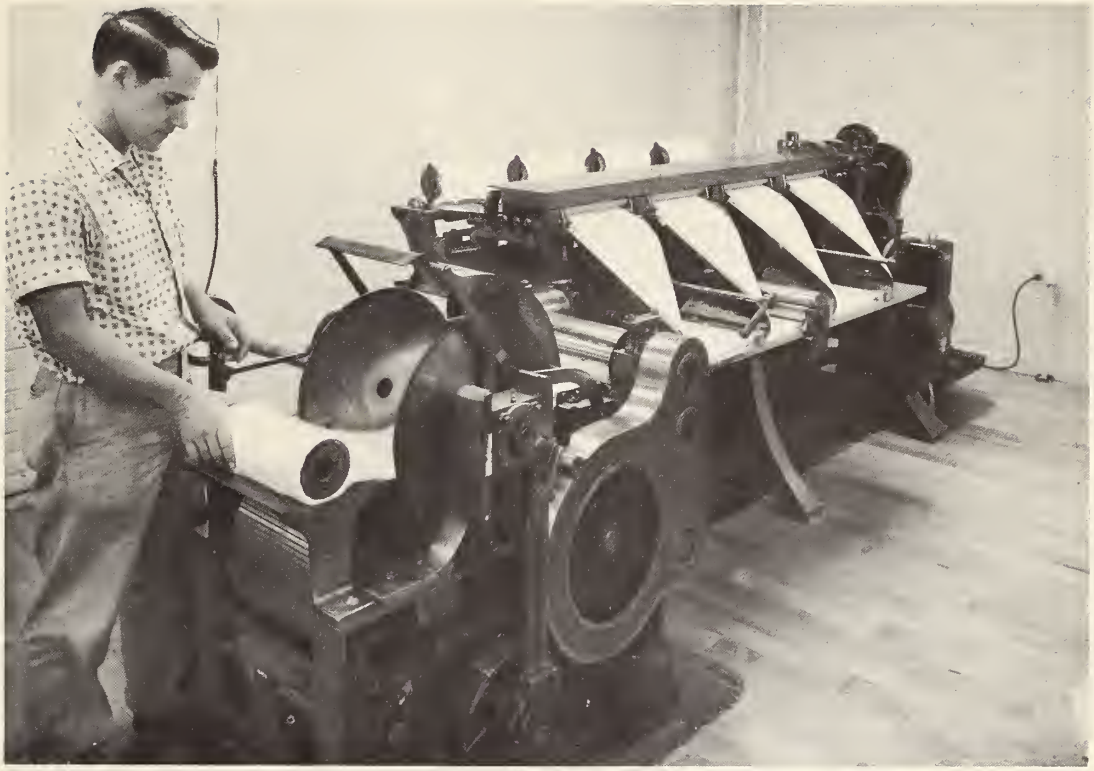

Figure 21.--Technician processing test sample through ribbon lapper.

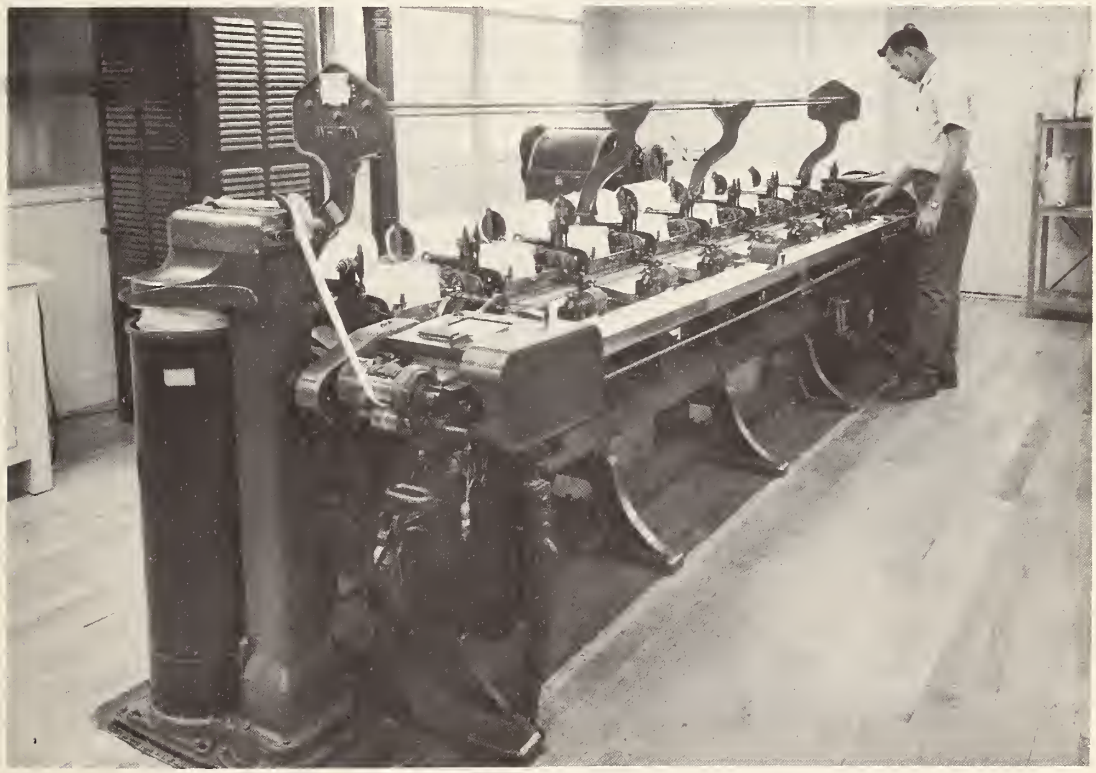

Figure 22.--Technician processing test sample through comber.

The drawing sliver is processed through a roving frame (fig. 24). This machine drafts or draws out the fibers into a much smaller strand, inserts enough twist to give adequate strength for further handling, and winds the strand onto a bobbin. This slightly twisted strand is called roving.

The roving is processed through a spinning frame (fig. 25). This machine drafts or draws out the strand to the size or yarn number required, inserts twist to form a firm strand, and winds it onto bobbins. This firmly twisted strand is called yarn. Most spinning test quality evaluations are made on the yarn produced by the spinning frame. Only enough yarn is produced in the regular spinning tests for these yarn quality evaluations, but additional yarns may be spun for fabric and chemical finishing evaluations. A relative measure of spinning end-breakage can also be obtained from an accelerated small scale test on a spinning frame (fig. 26).

When fabric evaluations are desired, extra yarns are spun for this purpose. The warp yarn is processed through a combination warping and slashing operation using a laboratory type machine (fig. 27). This machine treats the yarn with a sizing solution consisting of starch and other ingredients, dries the treated yarn, and winds the desired number of ends on a loom beam. The sizing treatment increases the resistance to chaffing during the weaving operation. Also, the filling yarn is wound into special packages to fit the shuttle of the loom. The warp yarn from the slasher and filling yarn from the winder are processed through a narrow loom (fig. 28). This machine interweaves the warp yarn, which runs lengthwise, and filling yarn, which runs crosswise, to produce cloth or fabric which is 12 inches wide. The grey or unfinished cloth is wound on a cloth roll as it is woven. This cloth is usually evaluated for quality in the grey or unfinished state.

When chemical finishing evaluations are desired, extra yarn spun in connection with the spinning tests are wound into skeins for this purpose. These skeins of yarn are then subjected to the following processes employing highly standardized procedures:

1. Bleaching (hydrogen peroxide)
2. Direct dyeing (calcodur blue)
3. Mercerizing (sodium hydroxide)

The bleaching and the dyeing processes are performed in a commercially built tank equipped with both steam and cold water outlets for temperature control, a cascade arm for revolving the material, and an electric pump for circulating the bath (fig. 29). The mercerizing process is performed in a special built tank designed to maintain uniform tension on the yarn during treatment (fig. 30). Bleached and dyed skeins are tested for color and mercerized skeins are tested for both luster and strength. The processing tests are performed in the following atmospheric conditions:

1. Picking, carding, combing, drawing, and roving processes at 60 $\pm$ 3 percent relative humidity and 75 $\pm$ 3 degrees F.

2. Spinning process at 65 $\pm$ 3 percent relative humidity and 75 $\pm$ 3 degrees F.

3. Weaving process at 80 $\pm$ 3 percent relative humidity and prevailing temperature.

4. Chemical finishing processes at prevailing atmospheric conditions.

5. Testing room at 65 ± 3 percent relative humidity and 70 ± 3 degrees F.

Spinning tests. These small-scale tests are provided for carded yarns, combed yarns, and combinations of both carded and combed yarns. In commercial practice, most cottons 1-1/8 inches and longer are manufactured into combed yarns. Although a considerable quantity of cotton shorter than 1-1/8 inches is used for combed yarns, the major part of it is used for carded yarns. Applicants for spinning tests should indicate in each instance whether a carded test, a combed test, or a combination of these two tests is desired.

The range of yarn numbers that can be spun from a cotton is dependent on its fiber length and other properties usually associated with length. Also the quality requirements are generally higher for products made from the finer yarn numbers than they are for products made from coarser yarn numbers. The finer numbers are, therefore, generally spun commercially from the longer staple cottons at relatively low-production rates. The coarser numbers are generally spun commercially from the shorter staple cottons at relatively high production rates. Four standard organizations for processing cotton into yarn have been set up to cover the range of staple length of cottons normally grown in this country in order to more nearly approach commercial practice. Each of these organizations includes two yarn numbers to provide data in terms of a relatively wide range. Carding rate, yarn numbers, twist multiplier, and comber settings that have been adopted as standard for various fiber lengths are shown in table 2. Other details for each of the four organizations are also shown in table 3.

The use of the standard organization, as based on the fiber length of a particular sample, is desirable in order that specific test results may be interpreted on the basis of data accumulated over a period of years. Any two standard laboratory yarn numbers (8s, 14s, 22s, 36s, 44s, 50s, and 60s carded or 14s, 22s, 36s, 44s, 50s, 60s, 80s, and 100s combed) that are within the spinnable limits of the particular cotton may, however, be specified by the applicant. The two standard yarn numbers selected are spun with the standard twist multiplier unless otherwise specified. Any one of the standard carding rates (6-1/2, 9-1/2, and 12-1/2 lb./hr. for carded yarns or 4-1/2 and 6-1/2, lb./hr. for combed yarns) may also be specified by the applicant. Unless the tests are performed according to the standard procedures as based on the fiber length of the particular sample, however, the general interpretation of results as listed in subsequent paragraphs is not applicable.

In evaluating the spinning test results, too much significance should not be attached to small differences shown for individual tests. In practical application, it should be remembered that a small difference in a single measurable property may be overshadowed by other properties. Conclusions, therefore, should be made only after consideration of all test results.

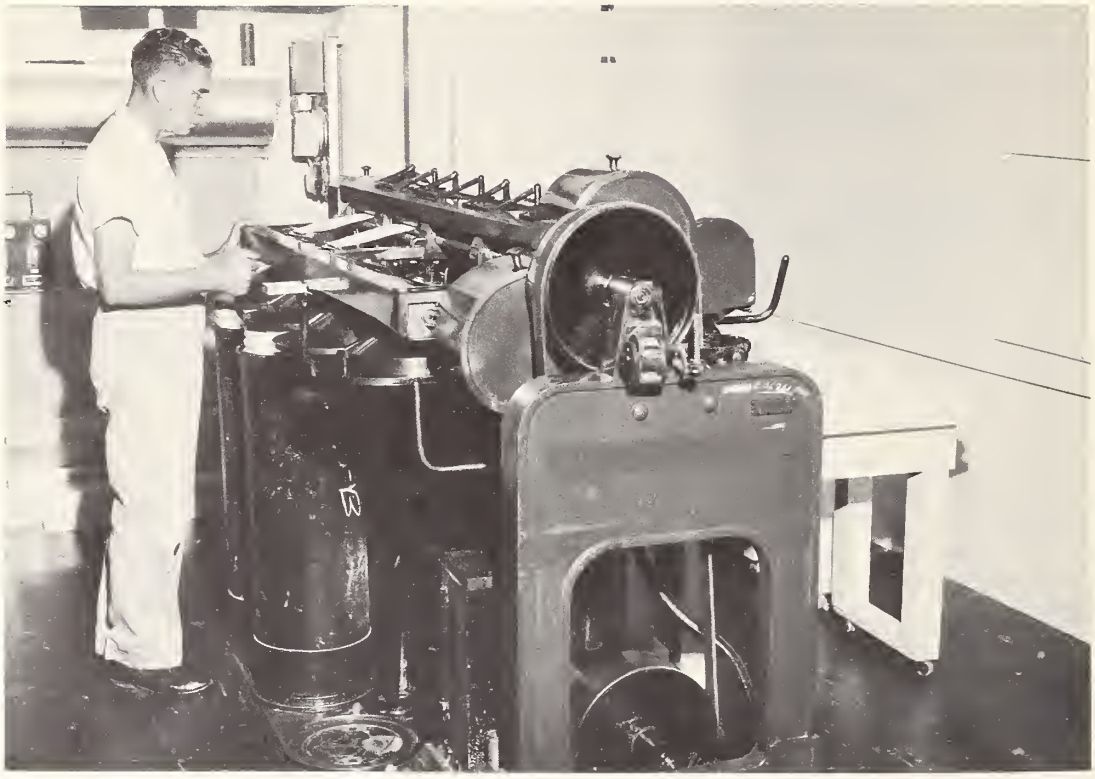

Figure 23.--Technician processing test sample through drawing

Figure 24.--Technician processing test sample through roving.

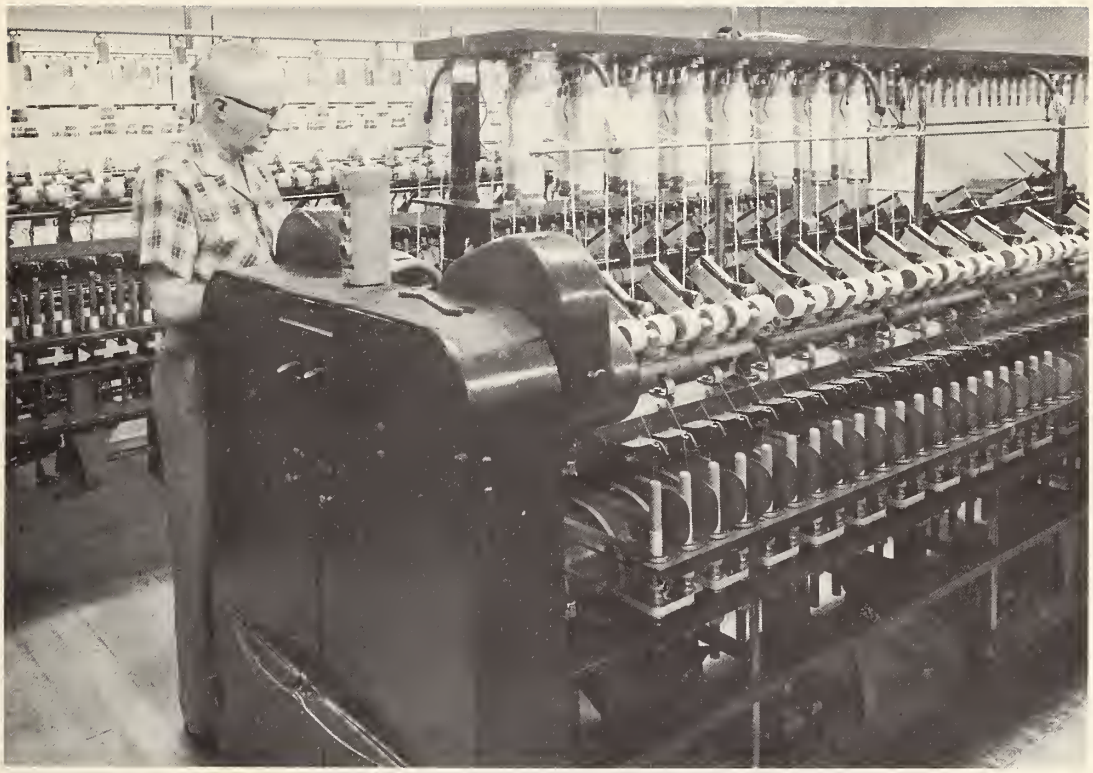

Figure 25.--Technician processing test samples through spinning.

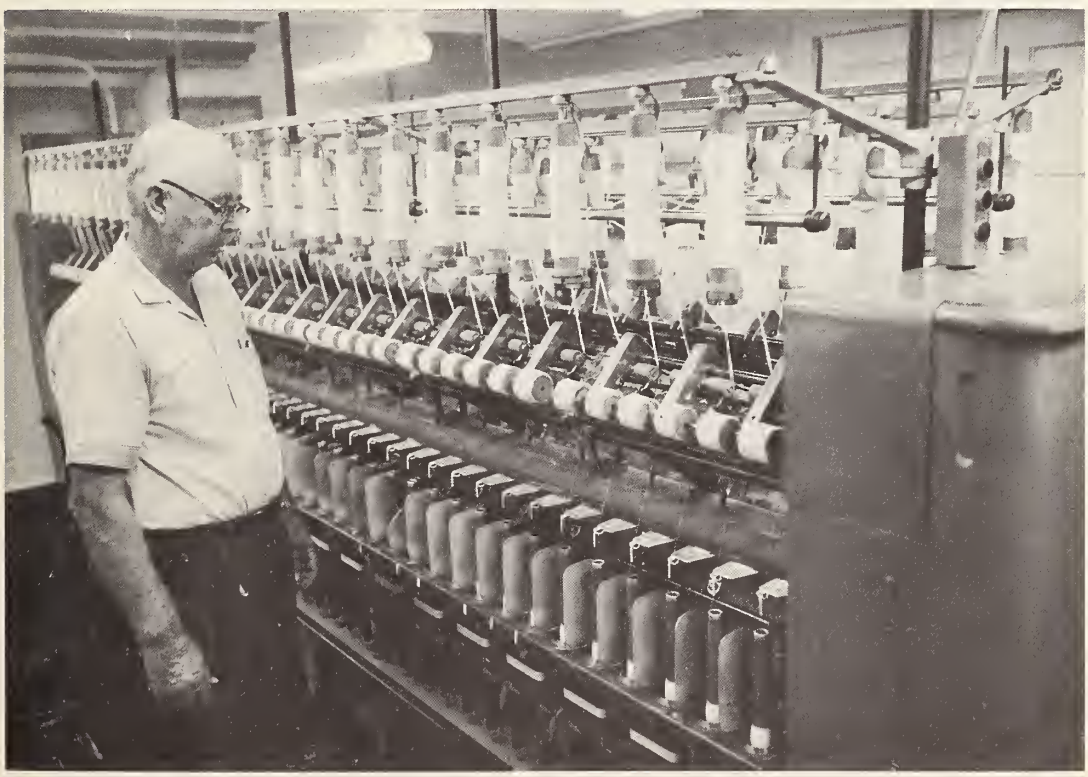

Figure 26.--Technician performing accelerated spinning end-breakage test.

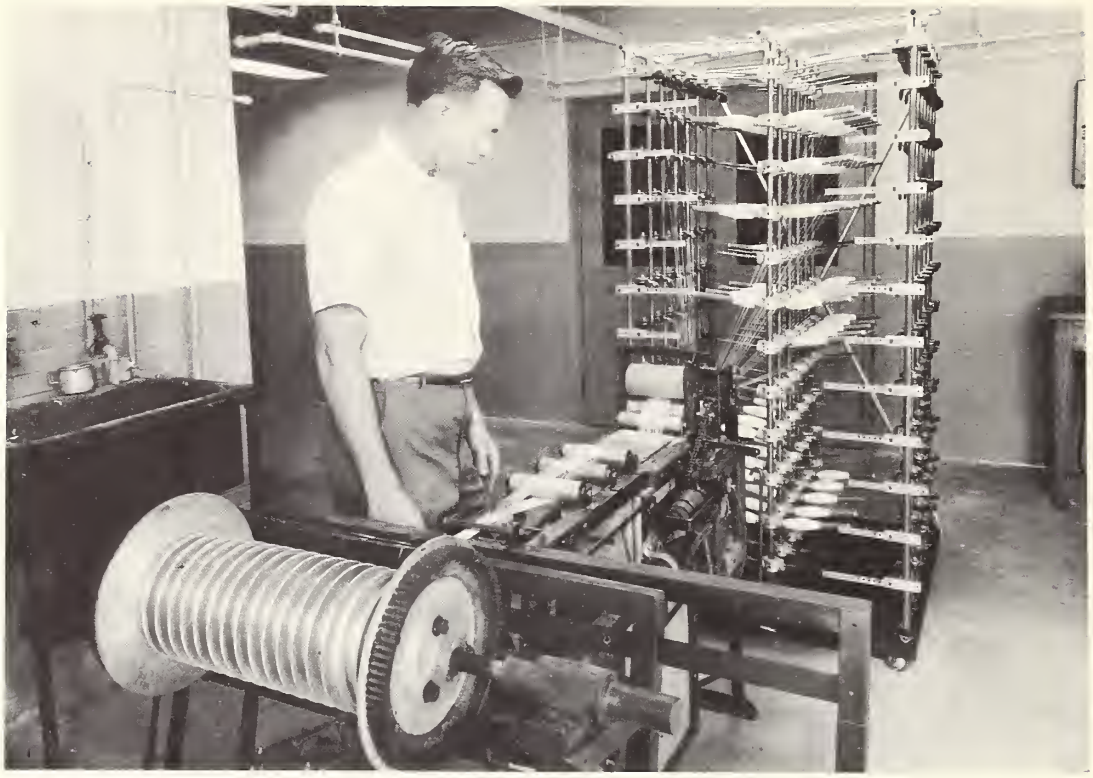

Figure 27.--Technician processing a test sample through warper slasher.

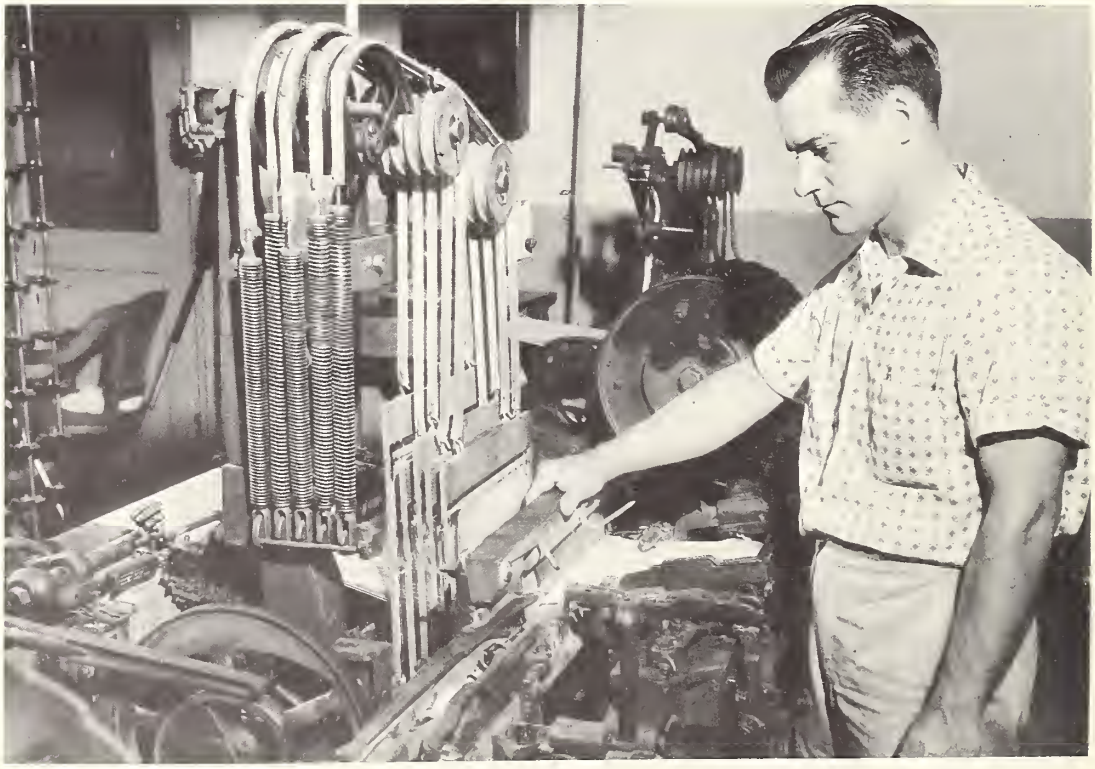

Figure 28.--Technician processing a test sample through a loom.

Figure 29.--Technician processing test samples for bleaching tests

Figure 30.--Technician processing test samples for mercerizing tests.

Table 2.--Carding rate, yarn numbers, spinning twist multiplier and comber setting which have been adopted as standard for various fiber lengths.

Upper half mean or 2.5% span length (Fibrograph)	Standard carding rate	Standard yarn numbers		Spinning twist multiplier	Standard comber setting
		Coarse	Fine		
Inches	lb./hr.	Number	Number	Number	Inches
Organization I - For Short staple cottons:					
Carded yarn tests only:					
0.66 and shorter	12-1/2	8s	22s	5.2	
0.67 - 0.82	12-1/2	8s	22s	4.8	
0.83 - 0.97	12-1/2	8s	22s	4.4	
Organization II - For Medium staple cottons:					
Carded yarn tests only:					
0.98 - 1.13	9-1/2	22s	50s	4.0	
Carded and combed yarn tests or combed yarn tests only:					
0.98 - 1.13 (Process in Organization III)					
Organization III - For Long staple cottons:					
Carded and combed yarn tests:					
1.14 - 1.28	6-1/2	22s	50s	3.8	0.48
Organization IV - For Extra Long staple cottons:					
Combed yarn tests only:					
1.29 and longer	4-1/2	50s	80s	3.6	0.54

Table 3.--Spinning test procedures for specified standard organizations

Process	Specified Organization 1/			
	I	II	III	IV
1. PICKER				
Standard atmospheric conditions:				
Temperature....degrees F.	75	75	75	75
Relative humidity....percent	60	60	60	60
Each test lot is processed through a finisher type picker twice to produce the specified weight of lap....ounces per yard	14	14	14	14
Type of beater	Kirschner	Kirschner	Kirschner	2-blade
Beater speed....r.p.m.	1,000	1,000	1,000	1,000
Settings:				
Feed roll to beater....inches	3/16	3/16	3/16	3/8
Girds to beater, top....inches	5/16	5/16	5/16	9/16
Girds to beater, bottom....inches	11/16	11/16	11/16	9/16
2. CARD				
Standard atmospheric conditions:				
Temperature....degrees F.	75	75	75	75
Relative humidity....percent	60	60	60	60
Picker lap fed....ounces per yard	14	14	14	11
Sliver delivered....grains per yard	50	50	50	40
Production rate....pounds per hour	12-1/2	9-1/2	6-1/2	4-1/2
Doffer speed....r.p.m.	11	8	6	4
Cylinder speed....r.p.m.	165	165	165	165
Flat speed....inches per minute	2-7/8	2-7/8	2-7/8	2-7/8
Licker-in-speed....r.p.m.	435	435	435	435
Cylinder wire....number	100	100	120	120
Doffer and flat wire....number	110	110	130	130
Settings:				
Feed plate to licker-in....inches	0.010	0.010	0.010	0.017
Mote knife to licker-in,top....inches	.012	.012	.012	.012
Mote knife to licker-in, bottom....inches	.010	.010	.010	.010
Licker-in screen, front....inches	.029	.029	.029	.029
Licker-in screen, back....inches	.017	.017	.017	.017
Licker-in to cylinder....inches	.007	.007	.007	.007
Flats to cylinder, back, center, and front..inches	.009	.009	.009	.009
Back plate to cylinder, top....inches	.029	.029	.029	.029
Back plate to cylinder, bottom....inches	.034	.034	.034	.034
Front plate to cylinder, top....inches	.029	.029	.029	.029
Front plate to cylinder, bottom....inches	.034	.034	.034	.034
Doffer to cylinder....inches	.007	.007	.007	.007
Cylinder screen, back....inches	.029	.029	.029	.029
Cylinder screen, center....inches	.034	.034	.034	.034
Cylinder screen, front....inches	3/16	3/16	3/16	3/16
Doffer comb to doffer....inches	.022	.022	.022	.022
3. SLIVER LAPPER (combed only)				
Standard atmospheric conditions:				
Temperature....degrees F.	-	-	75	75
Relative humidity....percent	-	-	60	60
Sliver fed, 20 each....grains per yard	-	-	50	40
Lap delivered....grains per yard	-	-	595	525
Speed....yards per minute	-	-	46	46
Roll settings (center to center):				
First to second....inches plus fiber length 2/	-	-	5/16	5/16
Second to third....inches plus fiber length 2/	-	-	9/16	9/16
4. RIBBON LAPPER (combed only)				
Standard atmospheric conditions:				
Temperature....degrees F.	-	-	75	75
Relative humidity....percent	-	-	60	60
Laps fed, 4....grains per yard	-	-	595	525
Lap delivered....grains per yard	-	-	610	610
Speed....yarns per minute	-	-	47	47
Roll settings (center to center):				
First to second....inches plus fiber length 2/	-	-	4/16	4/16
Second to third....inches plus fiber length 2/	-	-	7/16	7/16
Third to fourth....inches plus fiber length 2/	-	-	10/16	10/16

For footnotes see next page.

Table 3.--Spinning test procedures for specified standard organizations--Continued

Process	Specified Organization 1/			
	I	II	III	IV
5. COMBER (Model D-4)				
Standard atmospheric conditions:				
Temperature.....degrees F.	-	-	75	75
Relative humidity.....percent	-	-	60	60
Laps fed, 8 each.....grains per yard	-	-	610	610
Sliver delivered.....grains per yard	-	-	50	40
Production per hour.....pounds	-	-	16	13
Setting of cushion plate to detaching roll....inches	-	-	.48	.54
Nominal waste.....percent	-	-	16 to 17	16 to 17
6. DRAWING FRAME (synthetic top rolls)				
Standard atmospheric conditions:				
Temperature.....degrees F.	75	75	75	75
Relative humidity.....percent	60	60	60	60
First process:				
Sliver fed, 6 each.....grains per yard	50	50	50	40
Sliver delivered.....grains per yard	60	53	53	42
Second process:				
Sliver fed, 6 each.....grains per yard	60	53	53	42
Sliver delivered.....grains per yard	70	55	55	44
Speed.....yards per minute	36	36	36	36
Roll settings (center to center):				
First to second.....inches plus fiber length 2/	4/16	4/16	4/16	4/16
Second to third.....inches plus fiber length 2/	7/16	7/16	7/16	7/16
Third to fourth.....inches plus fiber length 2/	10/16	10/16	10/16	10/16
7. LONG DRAFT ROVING (8 x 4, 2 apron type)				
Standard atmospheric conditions:				
Temperature.....degrees F.	75	75	75	75
Relative humidity.....percent	60	60	60	60
Sliver fed.....grains per yard	70	55	55	44
Roving delivered.....hank	1.10	1.80	1.80	4.25
Spindle speed.....r.p.m.	1235	1235	1235	1235
Roll settings (center to center):				
First to second, standard.....inches	2-1/4	2-1/4	2-1/4	2-1/4
Third to fourth.....inches plus fiber length 2/	1/4	1/4	1/4	1/4
8. LONG DRAFT SPINNING (two apron type):				
Standard atmospheric conditions:				
Temperature.....degrees F.	75	75	75	75
Relative humidity.....percent	65	65	65	65
Roving fed single.....hank	1.10	1.80	1.80	4.25
Twist multiplier.....number	4.4	4.0	3.8	3.6
Carded yarns.....number 3/	8s & 22s	22s & 50s	22s & 50s	-
Combed yarns.....number	-	-	22s & 50s	50s & 80s
Spindle speed.....r.p.m. 4/	9000	9000	9000	9000
Roll settings (center to center):				
First to second, standard.....inches	2-1/16	2-1/16	2-1/16	2-1/16
Second to third, standard.....inches	1-3/4	1-3/4	1-3/4	1-3/4

1/ Based on Fibrograph length as shown in table 2.

2/ Allowances shown are in addition to Fiber lengths in terms of "pulls" made on card sliver which are estimated from Fibrograph lengths used in laboratory procedure.

3/ Additional yarn may also be spun on a 96 spindle wide gauge frame at 9,000 r.p.m. spindle speed to determine the spinning potential yarn number or the finest yarn number that can be spun without end-breakage.

4/ All standard numbers are spun on narrow gauge frame with spindle speed of 9,000 r.p.m. except for 8s which are spun on a wide gauge frame with spindle speed of 5,500 r.p.m.

The procedures used in performing the spinning tests were revised in 1961 to include heavier weights for laps, slivers, and rovings than those used previously. They also include spinning from single roving instead of double roving. These revisions reflect similar changes that have taken place in the cotton textile industry since the mid-1940's when long-draft systems were adopted for both the roving and spinning processes in the routine spinning test procedure. The 1961 changes were designed to bring the laboratory processing procedures more in line with current cotton textile mill practices and thus make the processing evaluations more applicable to present day mill operations. Spinning test results obtained prior to the revision in 1961 may be compared with those obtained currently after proper adjustments to make them comparable. The level of the results obtained by the 1961 revised procedures as compared to those obtained previously is as follows:

1. Results on essentially the same level:

    a. Picker and card waste
    b. Neps in card web
    c. Strength of combed yarns
    d. Appearance of carded and combed yarns
    e. Imperfections in carded and combed yarns

2. Results on significantly different levels:

    a. Strength of carded 8s yarn approximately 10 percent lower by the new procedure
    b. Strength of carded 22s and 50s yarns approximately 5 percent lower by the new procedure

The results of tests conducted on a large number of lots of cotton provide "bench marks" as described in subsequent paragraphs for the evaluation of specific test results.

Manufacturing waste. The manufacturing waste for a sample of cotton is important because excessive waste increases the cost of processing. The percentage of waste extracted by the picking and carding processes in performing a spinning test provides a measure of manufacturing waste. There is an average relationship between this waste and grade which is an indication of the waste content of a cotton. As the quantity of waste extracted by the picker and card for particular grade is affected by the characteristics of the fiber, the nature of the extraneous material, and whether the grade designation was lowered because of poor color, there are variations from the average relationship in the results for individual samples. Also, the rate at which the samples are carded affects the picker and card waste values because the more thorough carding action obtained when the carding rate is decreased extracts a larger quantity of waste. The longer staple cottons are generally carded at a lower rate than the shorter cottons in order to obtain acceptable yarn quality. Tests performed in recent years on samples of cotton from bales used in the standards and from surveys of the crop, show the following average relationship of picker and card waste to grade:

American upland grade	Average picker and card waste percent	American Egyptian grade	Average picker and card waste percent
Good Middling	6.3	1	7.0
Strict Middling	6.4	2	8.5
Middling	7.1	3	10.0
Strict Low Middling	8.2	4	11.4
Low Middling	9.7	5	12.9
Strict Good Ordinary	11.2	6	14.4

Data source - 2897 lots tested from crops of 1960-62 for American upland and 158 lots tested from crops of 1956-60 for American Egyptian.

When combed yarn tests are requested, the percentage of waste removed by the comber is furnished in addition to the picker and card waste. The shorter staple cottons are processed through the comber with a closer setting than that for the longer staple cottons because smaller comber waste percentages are usually extracted from this cotton in commercial practice.

Special studies and practical experience have indicated the following approximate reproducibility of the picker and card waste results:

Test measurement	Significant difference
Picker and card waste (percent)	1.0

Neps in card web. A desirable feature of any cotton is its relative freedom from neps, because they may be a source of trouble in the manufacturing and finishing of yarns and fabrics. The occurrence of neps in appreciable numbers detracts from the appearance of those products. This is especially true when they are to be dyed or printed because neps absorb dyes differently and appear as spots on the material. A determination of the number of neps per 100 square inches of card web during the processing of each spinning test lot provides a measure of the nep content. This determination is based on 10 specimens of card web totaling 360 square inches and is evaluated independently by two technicians (fig. 31).

When the nep count is high, the cotton is likely to produce rough and neppy yarns. The longer staple cottons are carded at a lower rate of production than the shorter staple cottons primarily because the longer staple cottons are more susceptible to the formation of neps. The following descriptive designations which are based on American upland cottons tested in recent years by using standard weight card sliver and carding rate for the particular cotton may aid in the comparison between cottons:

Neps per 100 square inches of card web	Descriptive designation
Below 17	Low
17 to 32	Average
33 to 50	High
Above 50	Very high

Data source - 2897 lots tested from crops of 1960-62.

Special studies and practical experience have indicated the following reproducibility of the spinning test results for neps in card web:

Test measurement	Significant difference
Neps per 100 square inches of web	3

Yarn strength. One of the most important and reliable tests of spinning quality is the strength of the yarns produced. Results of skein strength tests on yarn have been shown by special studies to be more closely related to both fabric strength and fiber properties than the results of single strand tests. Yarns produced in the spinning tests are wound into skeins on an automatic reel (fig. 32). These skeins of yarn are tested for strength on a pendulum-type tester (fig. 33) and are weighed to obtain the actual yarn number. The results of these tests are based on the average of 25 skeins for each yarn number.

High yarn strength is desirable because it increases the usefulness of a given cotton and also indicates good spinning and weaving performance. There is an average relationship between yarn strength and staple length but it varies for individual cottons because of differences in the characteristics of the fiber. Tests performed in recent years on samples of cotton from bales used in the standards and from surveys of the crop have shown approximately the following relationship of yarn strength to staple length:

Type of cotton, kind of yarn and staple length group	Average yarn skein strength		
	Coarse (pounds)	Fine (pounds)	Average (lb.x No.)
American upland:			
Carded yarns:			
Short staple	294 (8s)	93 (22s)	2199
Medium staple	108 (22s)	38 (50s)	2138
Long staple	130 (22s)	48 (50s)	2630
Combed yarns:			
Long staple	143 (22s)	53 (50s)	2898
American Egyptian:			
Combed yarns:			
Extra long staple	71 (50s)	40 (80s)	3375

Data source - 2897 American upland lots tested from crops of 1960-62 and 158 American upland lots tested from the crops of 1956-60.

Special studies and practical experience have indicated the following approximate reproducibility of the spinning test results for yarn skein strength:

Test measurement	Significant difference
Strength of 8s yarn	8 pounds
Strength of 22s yarn	4 pounds
Strength of 50s yarn	2 pounds
Strength of 80s yarn	1 pound
Average of 2 yarn numbers	80 break factor

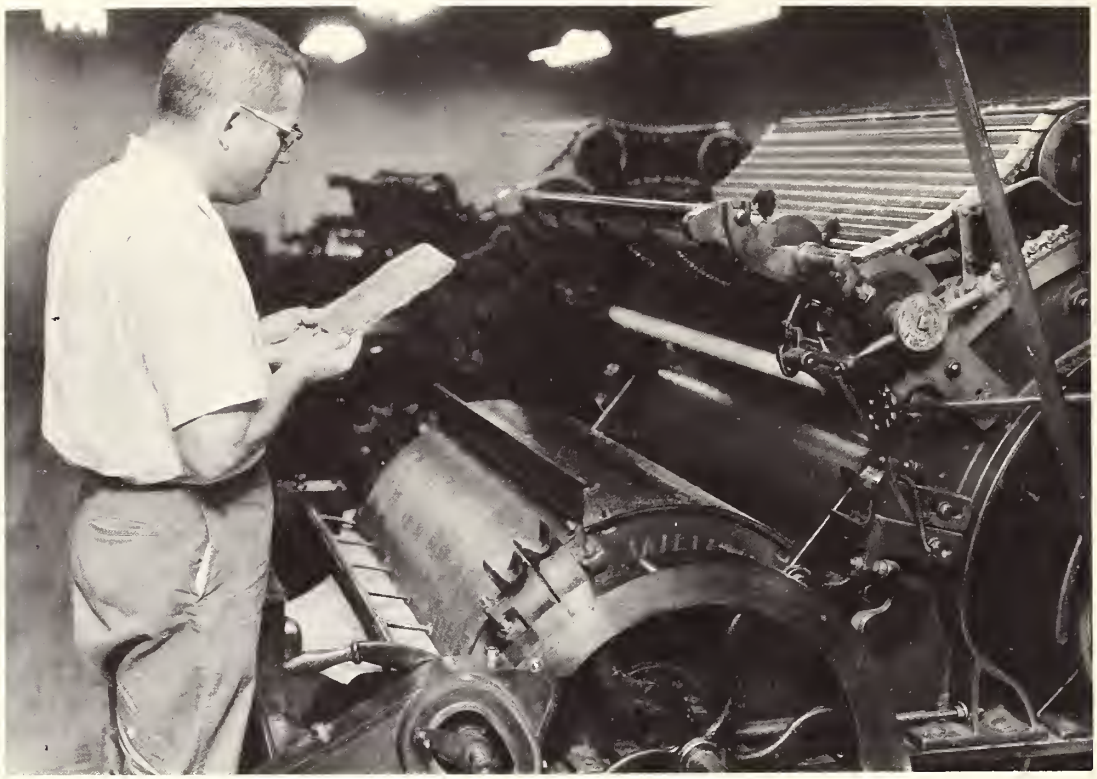

Figure 31.--Technician performing nep test on specimens of card web.

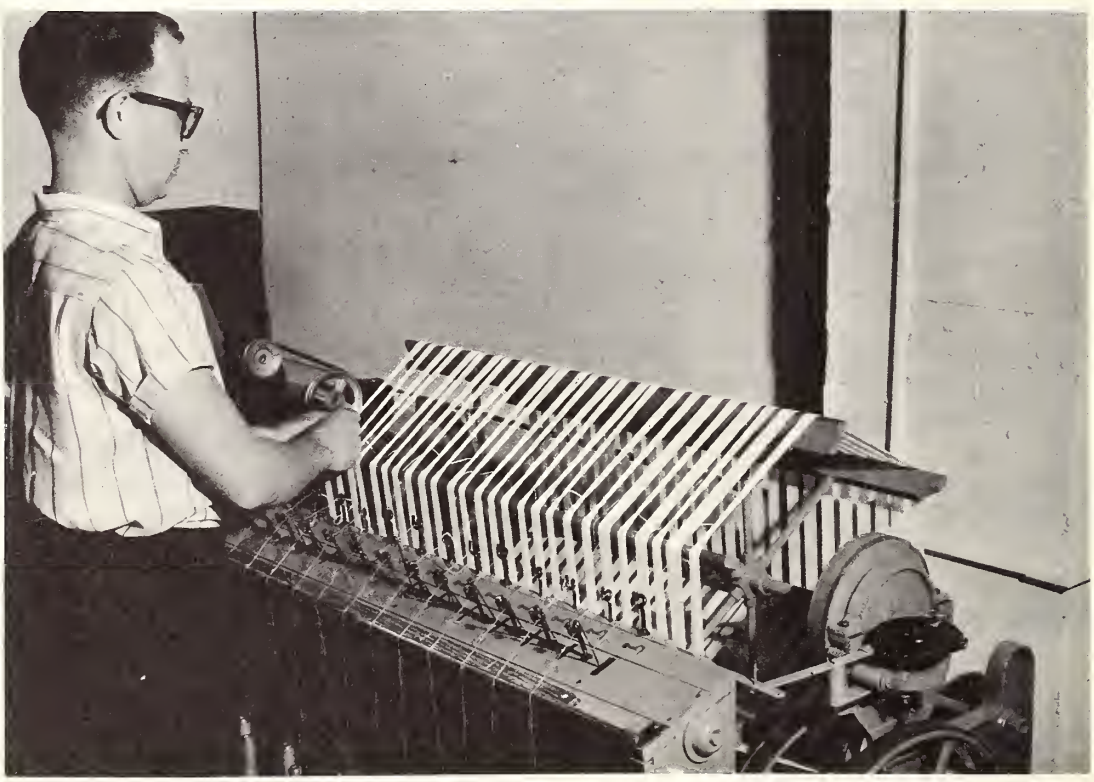

Figure 32.--Technician processing test samples on the reel.

Yarn appearance. The appearance of the yarn in many types of woven and knitted materials is a very important quality factor. Yarns produced in the spinning tests are wound on black boards (fig. 34) for appearance tests. These boards are evaluated by visual comparisons (fig. 35) with photographic standards (fig. 36) which have been adopted by and are available from the American Society for Testing Materials. The relative eveness, smoothness and freedom from foreign materials of the yarn on one board are considered by three technicians in making this evaluation. The yarn appearance grade for each yarn number and the average index for the two yarn numbers are reported for each spinning test. The following descriptive designations based on American cottons tested in recent years will aid in the comparisons between cottons:

Type of cotton, kind of yarn and staple length group	Average yarn appearance		
	Coarse (index)	Fine (index)	Average (index)
American upland:			
Carded yarns:			
Short staple	111 (8s)	100 (22s)	106
Medium staple	107 (22s)	95 (50s)	101
Long staple	102 (22s)	91 (50s)	96
Combed yarns:			
Long staple	108 (22s)	99 (50s)	104
American Egyptian:			
Combed yarns:			
Extra long staple	117 (50s)	108 (80s)	112

Where: A grade = 130 index, B+ = 120, B = 110, C+ = 100, C = 90, D+ = 80, D = 70, and BG = 60.

Data source - 2897 American upland lots tested from crops of 1960-62 and 158 American Egyptian lots tested from crops of 1956-60.

Special studies and practical experience have indicated the following approximate reproducibility of the spinning test results for yarn appearance:

Test measurement of yarn appearance	Significant difference
Yarn appearance:	
Each yarn number	1/2 grade or 10 index points
Average of 2 yarn numbers	5 index points or 1/4 grade

Yarn imperfections. An instrument measurement of one of the factors of yarn appearance is provided by yarn imperfection tests. Yarns produced in the spinning tests are tested on "neptel" instruments (fig. 37) which electronically count the abrupt changes in the silhouette of the yarn while passing it through a beam of light. The results of these tests are expressed as the number of imperfections per 50 yards of yarn and are based

Figure 33.--Technician performing skein strength tests.

Figure 34.--Technician winding a yarn appearance board.

on the average of 10 determinations for each yarn number. These results are more highly correlated with fiber properties than either neps in card web or yarn appearance. The following descriptive designations based on American upland cottons tested in recent years will aid in evaluating the spinning test results for yarn imperfections:

Type of cotton, kind of yarn and staple length group	Average yarn imperfections		
	Coarse (number)	Fine (number)	Average (number)
American upland:			
Carded yarns:			
Short staple	62 (8s)	41 (22s)	52
Medium staple	27 (22s)	19 (50s)	23
Long staple	27 (22s)	21 (50s)	24
Combed yarns:			
Long staple	19 (22s)	16 (50s)	18

Data source - 2897 lots tested from the crops of 1960-62.

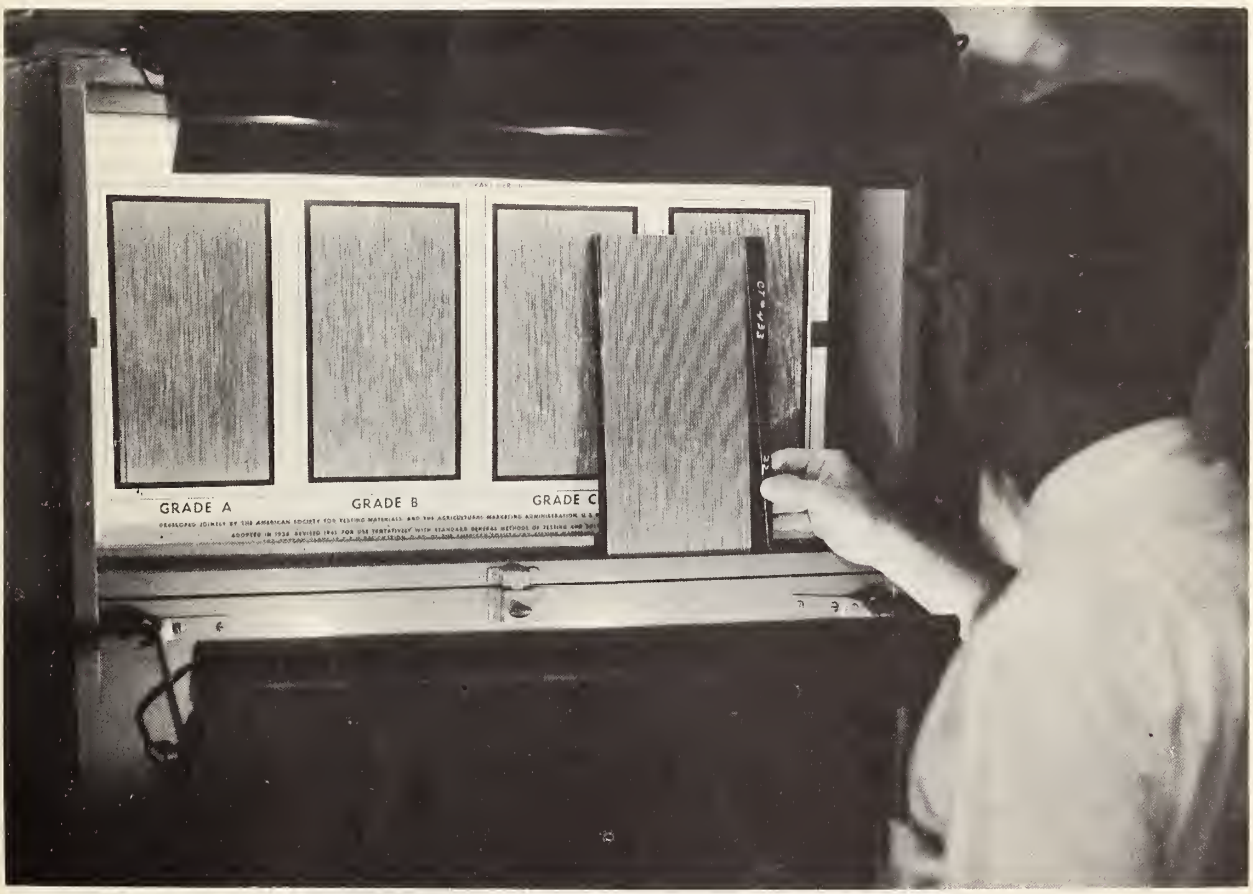

Figure 35.--Technician performing yarn appearance tests.

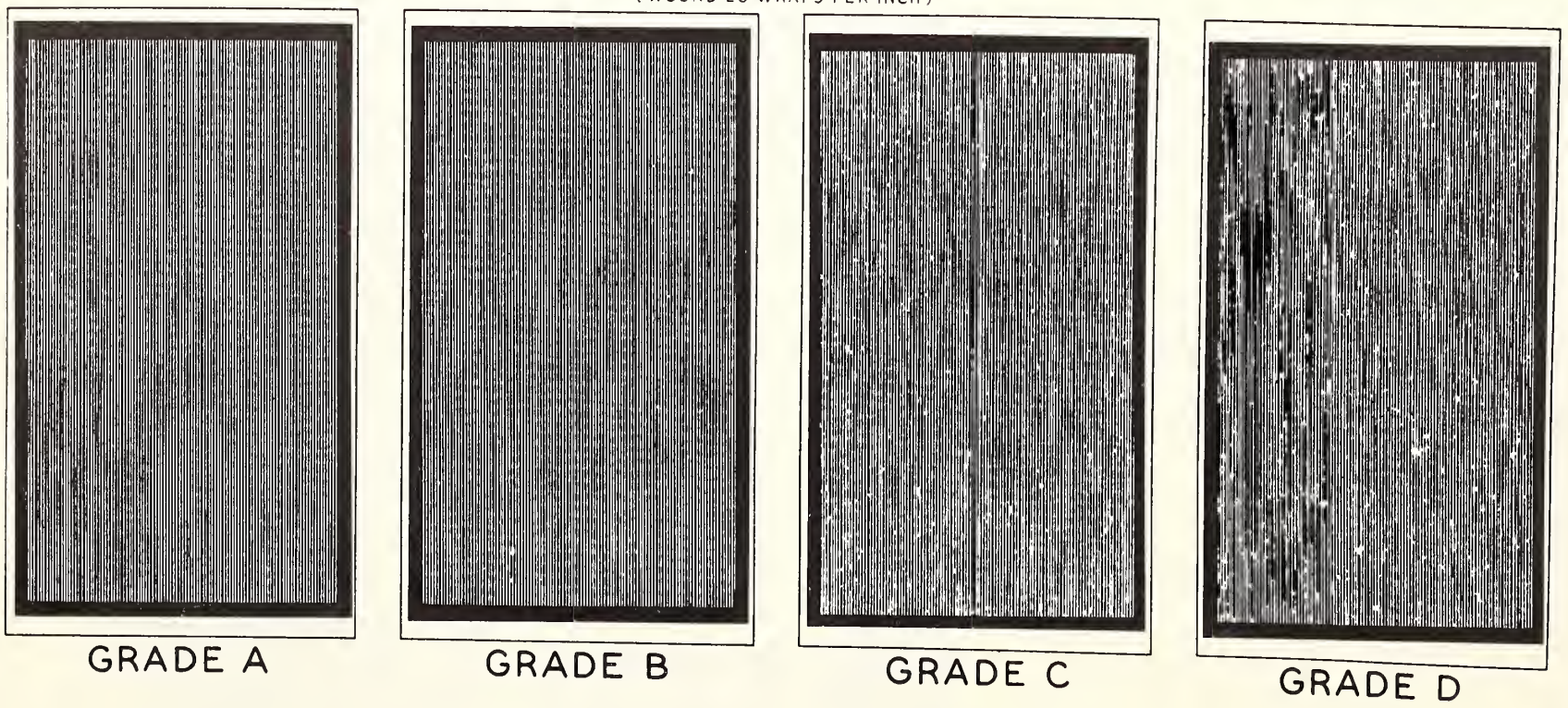

Figure 36.--Photographic standards for yarn appearance.

Special tests and practical experience have indicated the following approximate reproducibility of the spinning test results for yarn imperfections:

Test measurement of yarn imperfections	Significant difference
8s carded yarn	3
22s carded yarn	2
50s carded yarn	2

Additional yarn. Yarns in addition to those included in the spinning tests may be desired for the specific purposes of an applicant. Any yarns desired may be spun in connection with spinning tests so long as they are within the spinnable range of the cotton and within the capabilities of the laboratory equipment. The spinning and testing of extra yarn are included in one test item and the spinning and furnishing of extra yarn for testing by the applicant are included in another item. The spinning of extra yarn with different amounts of twist and testing these yarns to determine the twist multiplier required to produce maximum yarn strength for specific cottons are included in a special item.

Weaving tests. This test is provided for the applicants who desire fabric quality evaluations in addition to the yarn quality evaluations obtained in the spinning tests. The fabric for this test may be woven either from yarns spun in connection with spinning tests or from yarns furnished by the applicant. Any standard fabric construction which the laboratory is equipped to produce may be specified by the applicant but the following standard sheeting is usually used for these tests:

68 x 72 construction
21s warp and 23.6s filling
4.9 oz. per yard

Specimens measuring 4 x 6 inches in both warp and filling directions are cut from the fabric produced. These specimens are tested by the grab method for warp-wise and filling-wise strength (fig. 38). Specimens are also tested for both warp and filling construction (fig. 39) and weight per yard. The average results reported are based on the number of tests required for each item to obtain reliable information.

Waste and nep test. This test is provided for the applicants who desire waste and nep evaluations without the other items included in the spinning tests. In performing these tests, the cotton is processed through the pickers and card for cleaning and waste removal in the same manner as for spinning tests. The percentage of picker and card waste and the average number of neps per 100 square inches of card web are reported. These results are discussed in preceding paragraphs under "manufacturing waste" and "nep content."

Chemical finishing tests. Information on the bleaching, dyeing, and mercerizing properties of different varieties and growths of cotton is very important to textile manufacturers. This information helps avoid problems that may result from blending cottons having different finishing properties.

Figure 37.--Technician performing yarn imperfection tests.

Figure 38.--Technician performing fabric strength tests.

These tests are provided for the applicants who desire bleaching, dyeing or mercerizing evaluations. The yarns for the finishing tests may be spun in connection with spinning tests or may be furnished by the applicant. Both carded and combed yarns are commonly used for the bleaching and dyeing tests but only the combed yarns are usually used for mercerizing tests.

Skeins to be bleached are wet out for 15 minutes in a solution of water plus wetting agent at 176 degrees F. with a ratio of 100 to 1 by weight of bath to yarn. Bleaching agents consisting of 0.6 percent sodium silicate and 2.0 percent hydrogen peroxide (35 percent strength) based on the weight of the yarn are then added to the bath. The bath temperature of 176 degrees F. is maintained while the skeins are rotated periodically for a two-hour bleaching period. After bleaching, the skeins are thoroughly rinsed and drained. They are then moved to a drying room and dried without tension at 120 to 130 degrees F. for four hours.

Yarns may be dyed either in the gray or after bleaching. The skeins to be dyed are wet out for ten minutes in a solution of water and wetting agent at 207 degrees F. with 200 to 1 ratio by weight of bath to yarn. The dye (calcodur blue 4G1 color index No. 533) is then added to the bath to provide 1-1/2 percent dye based on the weight of the yarn. The bath temperature is maintained at 207 degrees F. while the skeins are rotated periodically for a ten-minute dyeing period. Sodium chloride to provide 30 percent based on the weight of the yarn is then added to the bath. The skeins are dyed in this bath for 30 minutes at 207 degrees F. before being rinsed in cold water and removed to a drying room. The skeins are dryed without tension at 120 to 130 degrees F. for four hours.

The skeins to be mercerized are subjected to a standard tension and are rotated through the caustic solution of 23 percent sodium hydroxide for four minutes. After four rinses, the skeins of yarn are rotated through a solution of .125 percent acetic acid for three minutes before being rinsed, drained, and removed to a drying room. They are dryed without tension at 120 to 130 degrees F. for four hours.

Color measurements are made on skeins of the grey, bleached, and dyed yarns for the finishing quality evaluations. These measurements are made on samples of parallelized yarn held under tension by using a Gardner Automatic Color Difference Meter and a special sample holder (fig. 40). The results are reported in terms of Rd and b, two of the three scales of the instrument. The R_d scale measures percentages of diffuse reflectance from 0 to 100. The b scale provides a measure of yellowness in the direction of plus b and blueness in the direction of minus b. The degree of either yellowness or blueness increases as the scale numbers increase. These color factors of R_d and b are not independent of each other and should be considered together in an overall interpretation. Index values to express the color results in terms of single numbers similar to those used for raw stock grade have been developed to facilitate the comparison between cottons with respect to chemical finishing. The index values for grey yarn color (fig. 41), for bleached yarn color (fig. 42) and for dyed yarn color (fig. 43) were developed on a basis of 100 for Middling grades and 70 for Good Ordinary grades.

Figure 39.--Technician performing fabric construction tests.

Figure 40.--Technician performing yarn color tests.

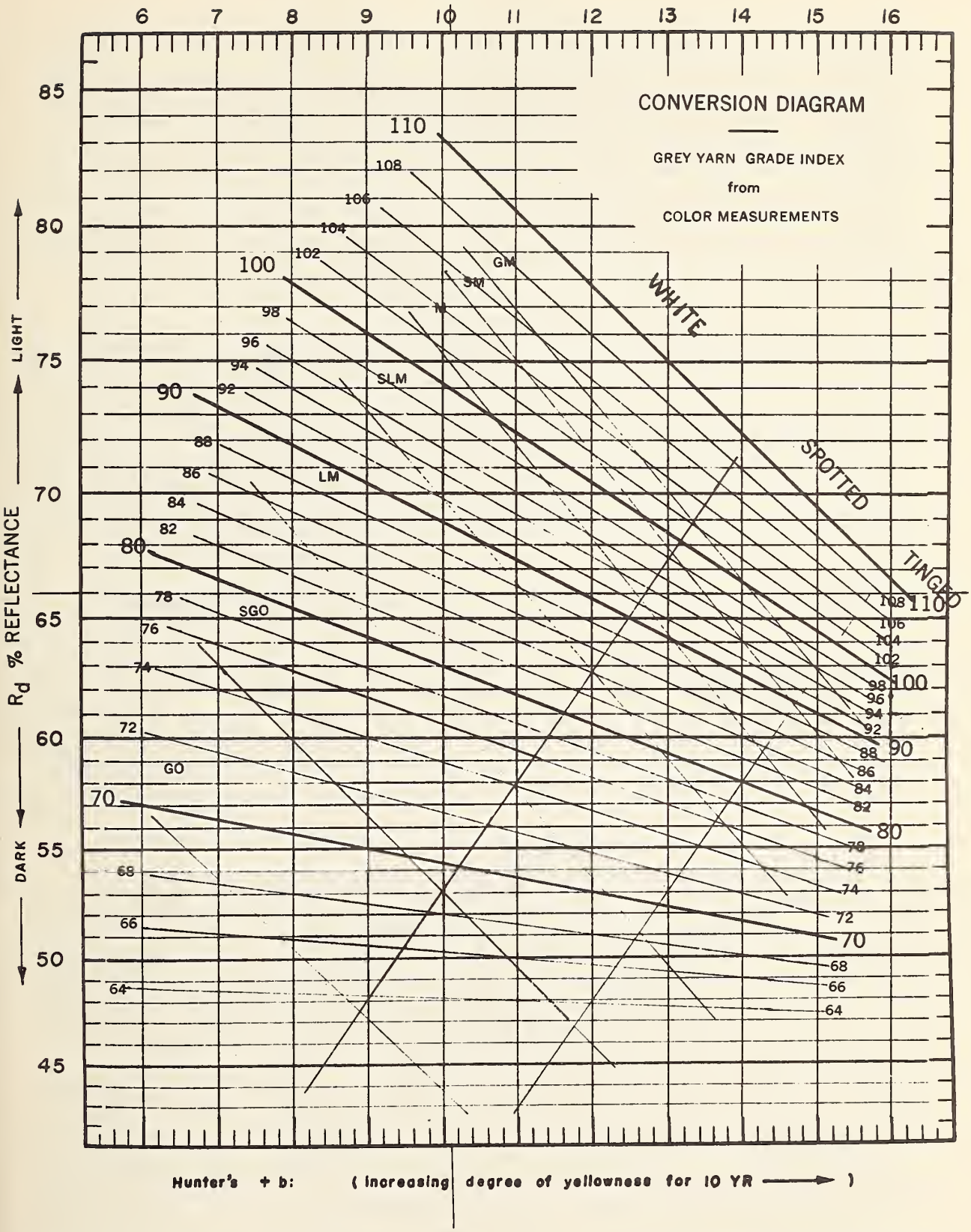

Figure 41.--Diagram for converting Rd and b color measurements of gray yarns to an index.

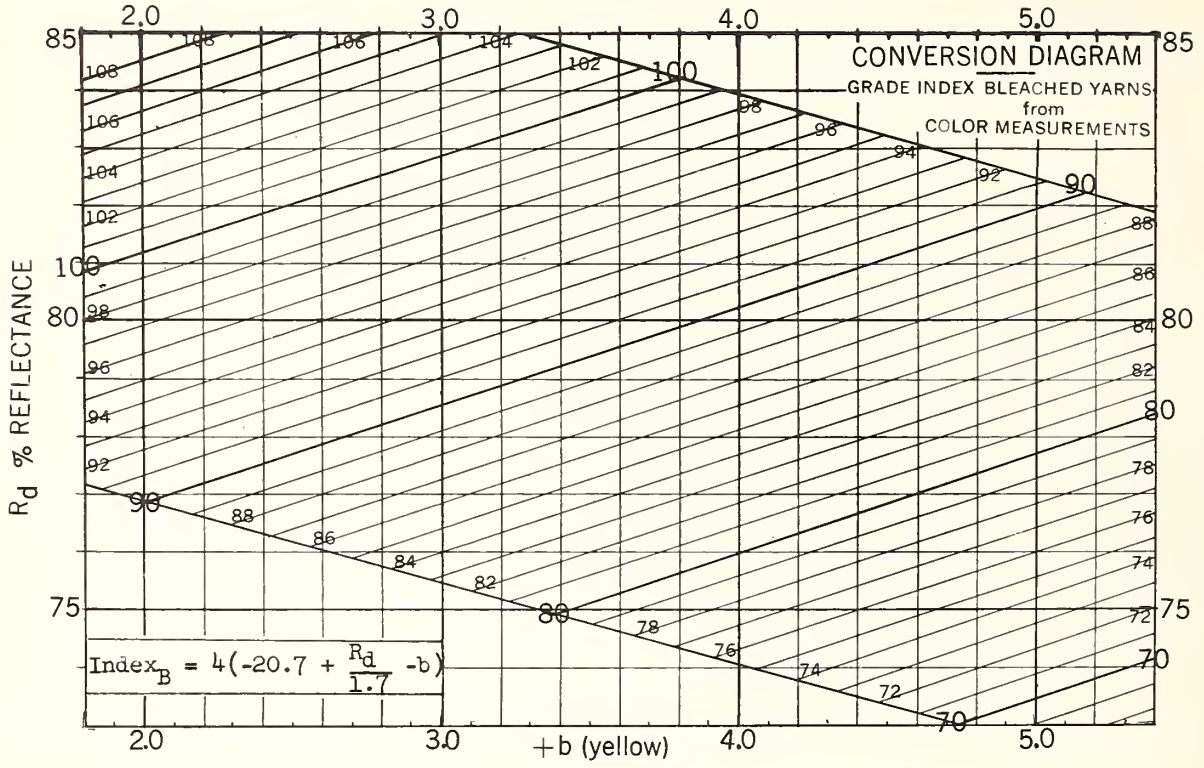

Figure 42.--Diagram for converting R_d and b color measurements of bleached yarn to an index.

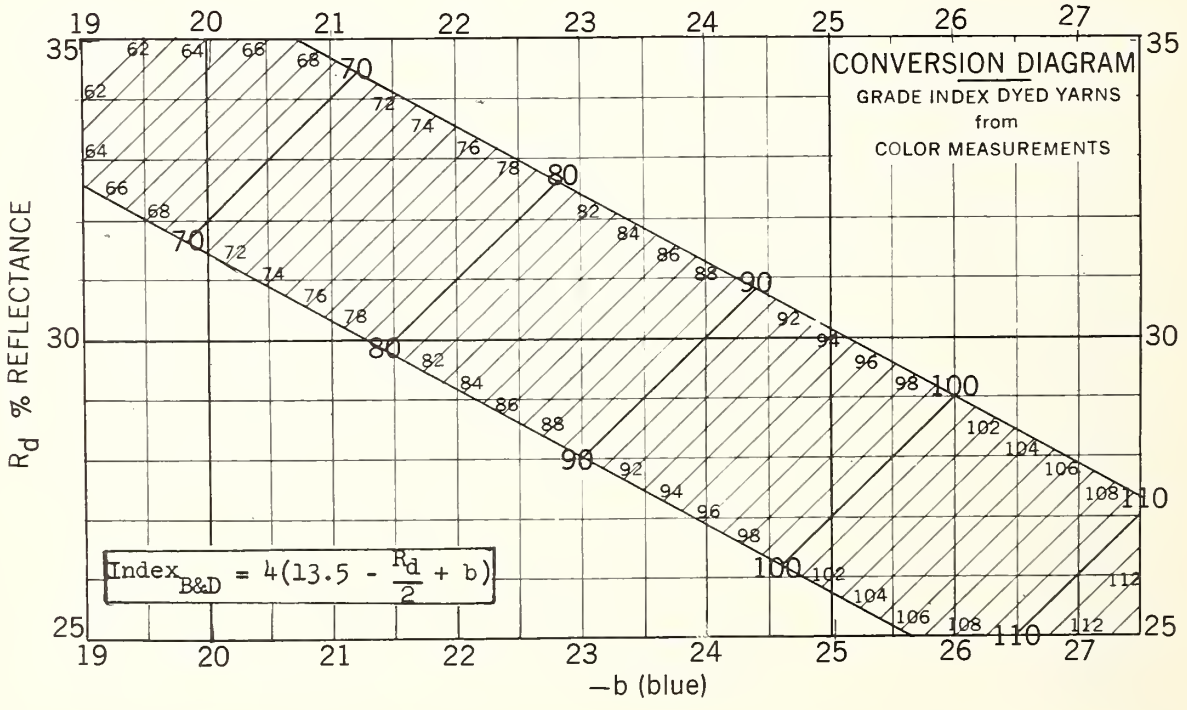

Figure 43.--Diagram for converting R_d and b color measurements of dyed yarns (after bleaching) to an index.

Both skein strength and luster measurements are made on the grey and mercerized yarns for the finishing test evaluations. The skein strength tests, on the mercerized yarns, are performed in the same manner as those described in connection with the spinning tests for the grey yarns. Luster tests are performed on a Hunterlab Cotton Lustermeter (fig. 44). Luster is measured as contrast gloss expressed as a ratio of the specular reflectance to the diffuse reflectance of a sample. This instrument reads directly in terms of 1-(D/S) which provides a scale from 0 percent (Matte surface) to 100 percent (high gloss) when multiplied by 100. Grey yarns measure approximately 30 to 40 percent on this scale and mercerized yarns range from 40 to 50 percent.

OTHER TEST ITEMS

Product quality tests. The relationship of the quality of the products produced in his own laboratory or mill as compared to the quality of the products produced in the laboratories of the Cotton Division from the same cottons is important to textile manufacturers. These tests are provided for the applicants who are interested in this type of evaluation. Special test items include the product quality tests performed in connection with spinning and other processing tests. They also include other similar tests which the laboratories are equipped to perform. The descriptions of these tests and their evaluations are included in the descriptions of the spinning and other processing tests.

Furnishing special items. Samples and data not normally furnished to the applicant are important for many special and unusual studies. Several test items provide for the furnishing of these items to applicants who have need for them. Identified samples taken at any of the stages of processing or testing may be furnished for the applicant to use in further study or examination. Copies of the test data work sheets which include the detailed data and the calculations may also be furnished for study and scrutiny by the applicant. Additional copies of the test reports or certified relisting of test results for selected samples from previous tests may also be furnished when requested.

VARIABILITY WITHIN COMMERCIAL BALES

In view of the high degree of variability for all measurable properties of cotton, the applicant for service tests should be fully aware of the limitations of the various tests that are imposed by such variability in the material tested. Otherwise, too much significance may be attached to small differences in the test results, and erroneous conclusions may be drawn. It is for this reason that data pertaining to the variability of cotton within individual bales are included in this report.

Variability of cotton within a single bale actually is much greater than is usually appreciated. Fibers from bolls produced on different parts of a single cotton plant develop at different times under different environmental conditions. As a result, they vary considerably in physical properties. Even on the same seed the fibers vary greatly, depending on their position on the seed. Frequently the cotton in a bale is harvested at different times and under different conditions. The cotton may come from different parts of the field and from different varieties. Under present procedures of ginning, a bale often contains some cotton from the bale ginned previous to it. There are other factors contributing to variability in cotton.

An indication of the extent of variability of the physical properties of cotton fibers within a single bale may be obtained from the data presented in table 4. Bales reported in this table were sampled in 12 positions through each bale, and the test results were based on tests made on the individual samples. Color variation in bales used in the standards are also shown in figure 45. It should be understood, however, that these data represent about the minimum of variability for commercial bales of cotton because these bales were selected as being uniform on the basis of samples from both sides before being purchased for use in the staple standards.

Table 4.--Variation within bales of cotton for selected fiber test measurements as compared to the reproducibility of the test results.

Test measurement	Number of bales tested	Variation within bales 1/		Significant difference 2/
		Range	Average	
Fibrograph length:				
Upper half mean (inches)	91	0.01-0.07	0.03	0.02
M/UHM Uniformity	91	1 -6	3	2
2.5% Span length (inches)	139	.02- .12	.04	.02
50/2.5 Uniformity	139	1 -5	2	2
Fineness and maturity:				
Micronaire reading	214	.0 - .7	.2	.2
Fiber strength:				
Zero gauge (1,000 psi)	93	1 -11	6	2
1/8-inch gauge (grams/tex)	130	.6 - 4.2	2.0	.5

1/ Based on tests of samples taken from 12 different positions throughout each bale. These bales were all selected as being uniform on the basis of samples from each side before being purchased.

2/ Based on special studies and practical experience for comparison of data in this table.

RELATIONSHIP OF TEST DATA TO PUBLISHED REPORTS

Users of the testing service may, upon request, have their names placed on a mailing list to receive publications dealing with cotton fiber and processing tests which are issued from time to time. Most of these publications report results of a survey of the fiber and processing tests of the cottons grown commercially in the United States each year. Samples of cotton for testing are collected from selected gin points all over the Cotton Belt at several intervals during the harvesting season. Results of the tests are reported in periodic publications during the harvesting season and are summarized in a comprehensive report after the end of each season. Other publications deal with specific subjects studied in connection with the cotton testing and standardization work of the Cotton Division. The data reported in these publications provide a basis for evaluating test results and for comparing the specific cotton submitted for tests with cottons grown commercially in the United States.

Figure 44.--Technician performing yarn luster tests.

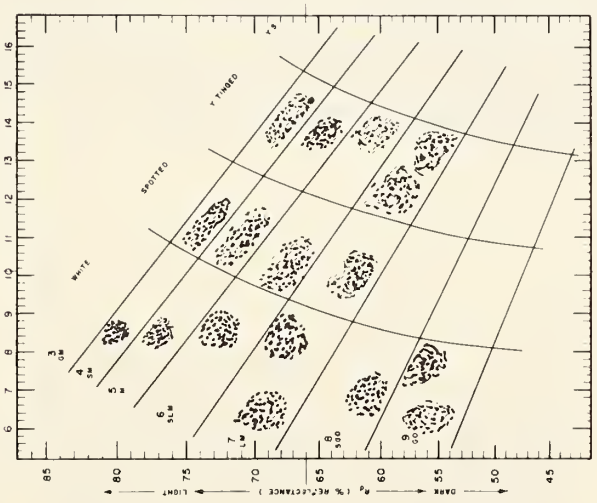

Figure 45.--Color variation within uniform bales. Each group of dots represents samples from one bale.

The relationships of the results of the fiber and processing tests published for the past 15 crop years have been studied by the use of multiple correlation analyses and the results published in AIB-257 and supplement. Results of five of the simpler classification and fiber tests were shown by these studies to be related almost as highly as the results of the most elaborate fiber tests to the results of the various processing tests. Only grade and staple classification or equivalent laboratory measurements of color, trash and length are required to provide good estimates of picker and card waste, trash in fabric, and grey yarn color. The addition of micronaire reading is required to provide good estimates of neps in card web, yarn appearance, yarn imperfections and dyed yarn color. The addition of both fiber strength and length uniformity is required to provide good estimates of yarn strength and spinning potential yarn number.

The correlation coefficient is a statistical measure for which a value of 1.00 indicates perfect relationship and a value of zero indicates no relationship. The increase in the relationship of grade and staple with various processing test items when three supplemental fiber tests are added is shown by the correlation coefficients in table 5.

The regression coefficients obtained in the relationship studies of fiber to processing tests are statistical measures which indicate the average change in the processing test associated with a one-unit change for each of the classification and fiber test items included in the analysis. These coefficients plus a constant provide a regression equation which can be used to estimate values for each processing test item. Average values for all of the classification and fiber test items when applied to the regression equations result in average results for each processing test item. When values covering the normal range for only one of the classification and fiber test items are substituted for the average value in the regression equations, the results obtained show the average association of this item with the processing test item. The standard error of the estimate is a statistical measure which indicates the accuracy of predictions made from the regression equations. Actual values normally should be within the range of plus or minus 1 standard error from the estimated value in approximately 68 percent of the cases.

Table 5.--Results of correlation analyses for the relationship of classification and supplemental fiber test measurements for medium staple American upland cotton, crop of 1962

Statistical items for specified classification and supplemental fiber test measurement 1/	Results of correlation analyses for processing test items 2/								
	Picker & card waste	Trash in fabric	Neps in card web	Strength of 22s yarn	Appearance of 22s yarn	Imperfections in 22s yarn	Grey yarn color	Bleached yarn color	Dyed yarn color
Average or mean values	7.8	92	25	104	110	26	98	101	103
Standard deviations	±1.0	± 9	± 10.4	±10.8	± 8	± 9	± 4.8	± 2.8	± 5.3
Correlation coefficient for:									
Grade and staple only	0.58	0.52	0.28	0.64	0.25	0.44	0.76	0.18	0.50
Grade and staple plus:									
Micronaire reading	.60	.56	.57	.66	.56	.64	.76	.21	.55
Micronaire reading and strength	.60	.56	.59	.72	.57	.64	.76	.31	.55
Micronaire reading, strength and length uniformity	.60	.56	.65	.81	.59	.64	.76	.33	.59
Regression coefficient for:									
Grade index	-0.12	+0.86	+0.23	+0.64	-0.20	-0.53	+0.73	+0.07	+0.36
Staple length	- .07	-1.37	-1.08	+4.95	+ .99	- .24	+ .43	+ .82	+1.33
Micronaire reading	- .35	+4.75	-11.02	-8.27	+9.03	-9.84	+ .37	+1.30	+2.17
Fiber strength	- .01	+ .03	- .21	+ .44	+ .09	+ .11	+ .01	- .11	- .10
Length uniformity	+ .01	- .10	-1.87	+2.73	+ .93	- .58	+ .20	- .25	+ .79
Standard error of estimates	±0.8	±7.2	±7.9	±6.4	±6.2	±6.6	±3.1	±2.6	±4.3

1/ Averages and standard deviations for the 491 samples are 96 ± 4.7 for grade index, 33.9 ± .8 for staple length, 4.4 ± .4 for micronaire reading, 84 ± 5.3 for fiber strength and 45 ± 1.7 for length uniformity.

2/ From Agricultural Information Bulletin No. 273, United States Department of Agriculture, Agricultural Marketing Service, Washington 25, D. C., April 1963. See AIB-258 for similar data for the 1961 crop and AIB-257 for the 1946-60 crops.